COMPARISON OF SHEAR BOND STRENGTH OF TWO DIFFERENT CERAMIC REPAIR SYSTEMS WITH TWO DIFFERENT SURFACE TREATMENTS ON METAL SURFACE-AN

IN-VITRO STUDY

Dissertation submitted to

The Tamil Nadu Dr. M.G.R. Medical University

In partial fulfilment of the degree of

MASTER OF DENTAL SURGERY

BRANCH I

PROSTHODONTICS AND CROWN & BRIDGE

2015-2018

CERTIFICATE

This is to certify that the dissertation entitled **"Comparison of shear bond strength of two different ceramic repair systems with two different surface treatments on metal surface – An in-vitro study"** is a bonafide record of the work done by Dr Soumya Mohan B Post graduate student during the period 2015-2018 under my guidance and supervision. This dissertation is submitted in partial fulfilment of the requirements for the award of MASTER OF DENTAL SURGERY IN, BRANCH I (PROSTHODONTICS AND CROWN AND BRIDGE) under THE TAMIL NADU Dr.M.G.R MEDICAL UNIVERSITY, CHENNAI. It has not been submitted (partial or full) for the award of any other degree or diploma.

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“In the end, though, maybe we must all give up trying to pay back the people in this world who sustain our lives. In the end, maybe it's wiser to surrender before the miraculous scope of human generosity and to just keep saying thank you, forever and sincerely, for as long as we have voices.”

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2	Nd :YAG	Neodymium yttrium aluminum garnet
3	ANOVA	Analysis Of Variance
4	Ni - Cr	Nickel Chromium

ABSTRACT

Introduction

Metal Ceramic Restorations are widely used in restorative dentistry with a high degree of success. On occasions, fractures do occur in ceramics due to trauma, flexure of metal or fatigue of ceramic. Fractured porcelains will affect aesthetics & function of prostheses which may warrant patients to seek immediate treatment[1].

Ceramic fracture may result from trauma, fatigue, occlusal prematurity, para- functional habits, poor abutment preparation, inappropriate coping design and incompatibility of coefficient of thermal expansion between ceramic and the metal structure. One option is to remake the restoration. This is both expensive and time consuming. Intra-oral chair side porcelain repair system is a quick, painless and highly patient acceptable procedure, without the removal of restoration or fabrication of new restoration[1]. Three kinds of fractures have usually been monitored at metal ceramic restorations: simple fractures (formed only within porcelain and metal does not get out of surface), mixed fractures (as well as porcelain fractures, metal gets out of surface), complex fractures (metal completely gets out of surface).Porcelain fractures are the most common cause of removing the prosthesis.

Fractured porcelain affects patients negatively in terms of aesthetic and function and requires to be changed. In this case, two different treatment options come to mind. The primary and ideal treatment option involves removing the prosthesis that not always applicable and financially costly. An alternative method is repair of fractured area with composite resin intraorally. Intraoral repair method offers some advantages such as, economic cost and time savings. But, the bond between restoration remained in the repaired area and repair material should be strong and resistant to the functional loads. In order to improve the bond between composite and fractured surfaces, many mechanical and chemical bond methods have been developed. To provide the mechanical bond; many surface treatments including roughening with diamond drills, sandblasting with aluminium oxide have been used for both metal and ceramic surfaces[46].

Intraoral repairs often involve bonding composite to fractured porcelain. Newer adhesive systems, currently referred to as multipurpose systems, include materials with recommended procedures for repair of porcelain[33].Of the many ceramic repair systems commercially available, Ivoclar ceramic repair system and Shofu ceramic repair system are used for the present study.

Aims and Objectives

The aim this study was to evaluate & compare the shear bond strength of two different Ceramic Repair Systems (Ivoclar & Shofu) with two different surface treatments (Sandblasting & Laser etching) on metal surface. The objectives were to estimate the most efficient ceramic repair system based on the obtained shear bond strength values and to estimate the most efficient surface treatment based on the obtained shear bond strength values.

Methodology

Twenty Cobalt Chromium blocks were made and ten such blocks were sandblasted with intra oral sandblaster and the remaining ten blocks were laser etched with ND: YAG laser. Five sandblasted blocks were coated with Ivoclar ceramic repair system and remaining five sandblasted blocks were coated with Shofu ceramic repair system. Five laser etched blocks were coated with coated with Ivoclar ceramic repair system and remaining five laser etched blocks were coated with Shofu ceramic repair system. All the twenty blocks were tested on universal testing machine for evaluating shear bond strength.

Results

Group I (Sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system) has the highest shear bond strength compared to all other groups.

Summary and Conclusion

Within the limits of the present study it can be concluded that :-

- Group I – sandblasted cobalt – chromium metal blocks coated with Ivoclar ceramic repair system showed highest shear bond strength than all other three groups.
- Surface treatment with sandblasting or air abrasion with 50µ alumina particles gave better result for shear bond strength assessment.

- For sandblasted groups, Ivoclar ceramic repair system gave the better shear bond strength value.
- For laser etched groups, Shofu ceramic repair system gave the better shear bond strength value.

However further clinical research is suggested in order to prove it as a reliable and successful treatment modality.

INTRODUCTION

De Chemant in 17 century introduced ceramics to dentistry for making denture teeth. Dental ceramics have various advantages like colour stability, radio-opacity, esthetics, and coefficient of thermal expansion similar to dentin, good compressive & abrasive resistance but also have drawbacks like low tensile strength, low edge strength & high brittleness. Subsequently, innovations were attempted to strengthen dental ceramics. The prevalence of fracture of metal ceramic restorations at the metal ceramic interface is approximately 2–5% and has been reported as the second greatest cause for the replacement of restorations after dental caries[1].

Ceramic failures can occur as simple, mixed or complex, fractured porcelains will affect aesthetics & function as they occur most frequently in regions that are quite visible, which may warrant patients to seek immediate treatment. Removal & reconstruction of the prosthesis is a costly affair & hence it is better to attempt repair with composite resins intra-orally, especially in less severe cases[2,3].

Most metal ceramic restorations may fracture in the form of chipping or deveneering of ceramic due to bond failure between ceramic and metal surface. Fracture can be from trauma, occlusal prematurity, para-functional habits, poor abutment preparation, inappropriate coping design and incompatibility of coefficient of thermal expansion between ceramic and the metal structure.

Intra-oral chair side repair is a quick, painless and highly patient acceptable procedure, with ceramic repair systems without removal of restoration or fabrication of new restoration. Repair of fractured metal ceramic crowns aims to re-establish the function & esthetics of restorations by using various repair materials. For the repair material to withstand functional loads, the bond between the repair material & remaining restoration must be strong & durable[3,4,5]. Intraoral repairs often involve bonding composite to fractured porcelain. Newer adhesive systems, currently referred to as multipurpose systems, include materials with recommended procedures for repair of porcelain[33].

Many repair agents such as cyanoacrylates, acrylic and composite resins were used but were partially successful due to esthetic and mechanical limitations. The earlier repair systems generally used two component silane coupling agents (silane and acid). It was designed to chemically bond composite to the silica (SiO_2) component of ceramic but had low shear bond strength. The recently introduced repair systems have 10 methacryloyloxydecyl dihydrogen phosphate (MDP), which recommends physical alteration of ceramic and metal substrates in conjunction with chemical agents such as metal primer, ceramic primer and improved silane coupling agents to promote adhesion of resin to fractured metal ceramic restorations[1,2].

A strong resin bond relies on micromechanical interlocking and chemical bonding to the ceramic surface, which requires roughening and cleaning for adequate surface activation. To promote a satisfactory adhesion between repair materials & surfaces to be repaired, specific treatment of the substrate must be performed. There are many surface treatments available to improve mechanical retention, out of which Sandblasting & Laser Etching are the two commonly used. These type of treatments improves the bond strength between the repair material & the surface of a fractured prosthesis[8].

In the present in-vitro study, the sandblasting of ceramic surfaces that are to be repaired is performed with a high speed stream of purified aluminium oxide particles (50µm) delivered by air pressure (30 to 40 psi) for approximately 15 seconds.

For doing sandblasting in patient's oral cavity, intraoral chairside sandblasters are available, the procedure is same as stated above. Care should be taken to avoid injuries to the surrounding soft tissues. As well as control the emission & spread of aluminium oxide particles over the operative area. This can be accomplished by using rubber dam isolation & high power suction systems.

In Laser etching, the surfaces of specimens are irradiated with Neodymium: YAG laser. Then a silane coupling agent is applied onto the surface & a ceramic repair system is bonded onto it. Recently some new surface conditioning methods on substrate surface has been developed like laser irradiation on zirconia or porcelain, nanostructure alumina coating on zirconia & ceramics and chemical vapour deposition of chloro-silanes & sulphur hexafluoride onto zirconia or ceramic surface.

Feldspathic ceramics (silica-based ceramic) are the conventional ceramic materials for metal–ceramic restorations and consist of a mixture of feldspar and quartz. They are frequently used to veneer metal frameworks and indirect restorations, such as inlays, onlays, and laminates[11,13].

Surface pre-treatment of porcelain increases surface area and creates micro-porosities on the surface, enhancing the potential for mechanical retention of the cementing medium. All-ceramic restorations have gained popularity among dentists and patients because of their favourable aesthetics and liability in conservative tooth preparations. Ceramics are still the most aesthetically pleasing materials available for prosthetic dentistry because of their high resistance to abrasion and compression, acceptable chemical stability, good biocompatibility, acceptable translucence, and fluorescent characteristics. In Fixed Prosthodontics 90% of the restorations are fabricated in dental ceramics. High brittleness & crack propagation in ceramics are its main disadvantages as a result of which fracture or chipping of ceramics from restoration can occur. Ease of repair of the restoration can be done intraorally itself without the removal of the restoration by ceramic repair systems[33].

Despite the fact that prosthetic use of full ceramic materials have developed and grown up, metal ceramic restorations have a large clinical usage in dentistry because of their mechanical strength. Nonetheless, the mostly seen clinical problem at metal-ceramic restorations is structure of fragile ceramic veneer. Fractures in general have been occurred due to several reasons such as, trauma, incompatible occlusal arrangements, parafunctional habits, flexural fatigue of metal infrastructure, incompatible thermal expansion coefficient between metal infrastructure and porcelain, insufficient dental preparation, porosities in the structure of porcelain, metal infrastructure design. Three kinds of fractures have usually been monitored at metal ceramic restorations: simple fractures (formed only within porcelain and metal does not get out of surface), mixed fractures (as well as porcelain fractures, metal gets out of surface), complex fractures (metal completely gets out of surface).Porcelain fractures are the most common cause of removing the prosthesis. Fractured porcelain affects patients negatively in terms of aesthetic and function and requires to be changed. In this case, two different treatment options come to mind. The primary and ideal treatment option involves removing the prosthesis that not always applicable and financially costly. An alternative method is repair of fractured area with composite resin intraorally. Intraoral repair method offers some advantages such as, economic cost and time savings. But, the bond between restoration remained in the repaired area and repair material should be strong and resistant to the functional loads. In order to improve the bond between composite and fractured surfaces, many mechanical and chemical bond methods have been developed. To provide the mechanical bond; many surface treatments including roughening with diamond drills, sandblasting with aluminium oxide have been used for both metal and ceramic surfaces. Hydrofluoric acid roughening, acidylophosphate fluoride or ammonium hydrogen bifluoride have been used for ceramic surfaces roughening. Regarding chemical bonding, adhesive primers and silane coating agents can be applied after mechanical surface treatments in order to strengthen bonding.

In addition, companies have intended to strengthen the bond between composite resin and metal ceramic surfaces by various primary and bond systems included in repair sets in themselves through developing adhesive systems. It has been intended to improve existing repair systems to exclude use of surface treatment application procedure and loss of time[46].

The present comparative study evaluates the shear bond strength of two commercially available ceramic repair systems (Ivoclar & Shofu), after surface pre-treatment (sandblasting & laser etching). Significance of recently developed ceramic repair systems in Prosthodontics has been the simulative factor for conducting the present study.

AIMS AND OBJECTIVES

AIMS & OBJECTIVES

Aims

To evaluate & compare the shear bond strength of two different ceramic repair systems (Ivoclar & Shofu) with two different surface pre-treatments (sandblasting & laser etching) on metal surface.

Objectives

- ✓ To compare the shear bond strength of two different commercially available ceramic repair systems.
- ✓ To evaluate the efficiency of surface treatment based on the obtained shear bond strength values.
- ✓ To determine the best commercially available ceramic repair system after surface pre-treatment.

REVIEW OF LITERATURE

Intraoral chair side repair system is a quick, painless & highly patient acceptable procedure, without removal of a restoration or fabrication of new restoration. There are very limited studies conducted to evaluate the shear bond strength of repair systems after different surface treatments[1,2]. The porcelain laminate veneer technique is widely used in prosthetic dentistry, because anaesthesia is not required for the preparation, removal of tooth tissue is reduced, and the aesthetic results are excellent. The key to this technique is the adhesion of composite to porcelain. The adhesion of dental resin to porcelain is achieved by the etching of the porcelain surface with hydrofluoric acid and by the use of silane coupling agents.

Newer generations of silane systems are composed of two or three solutions; one is the silane coupler, and the other is the acid component of the solution. Heat treatment or acid catalysis increases the bond strengths of the polymers to ceramics treated with silane coupling agents because of the effective initiation and progress of the formation of siloxane bonds between the silane coupling agent and the porcelain surface. Heat treatment is not a clinically available system, so acid solutions of these newer silane agents are used to facilitate the reaction of silane coupling agent to the porcelain surface. Surface treatments that do not require hydrofluoric acid etching of the porcelain, such as phosphoric acid etching or roughening with diamond burs, have been used. However, earlier systems relied on the mechanical retention of the composite produced by the hydrofluoric acid etching for their adhesiveness[26].The literature review had shown that there are many different surface pre-treatments and ceramic repair systems available.

Kalra A *et al*. 2015 [1] evaluated the shear bond strength of two intra-oral porcelain repair systems to repair metal- ceramic restoration after three different surface treatments and concluded that the shear bond strength of ceramic repair system with 40% phosphoric acid etching showed highest value as compared to other system and surface treatment used in their study.

Chung K *et al*. 1997 [2] analysed the bonding strengths of porcelain repair systems with various surface treatments and concluded that the mean bond strength of composite bonded to base alloy surface after sandblasting in six porcelain repair systems ranged from 8.0 to 17.0 Mpa. The study suggested that metal substrates treated with sandblasting and porcelain treated with either hydrofluoric acid or sandblasting can increase repair strength.

Blatz M *et al.* 2003 [3] reviewed resin ceramic bonding and concluded that the resin bonded to silica-based ceramics is well documented through numerous in vitro investigations. Preferred surface treatment methods are acid etching with hydrofluoric acid solutions (2.5% to 10% for 2 to 3 minutes) and subsequent application of a silane coupling agent.

Santos JG *et al.* 2006 [4] compared shear bond strength of metal ceramic repair systems and concluded that for the metal substrate (nickel-chromium alloy) the CoJet Sand/Z100 group showed statistical superiority compared to the other groups. For porcelain, the Scotch Bond Multipurpose

Plus/Z100 (control group), the CoJet Sand/Z100, and Bistite II DC/Palfique groups showed the highest shear bond strength values.

Yavuz T *et al.* 2013 [5] evaluated the effects of different surface treatments on shear bond strength in two different ceramic repair systems and concluded that the shear bond strengths of the resin cements tested on ceramics after surface treatments varied in accordance with the type of ceramic.

Jochen DG *et al.*1977 [6] evaluated the effect of composite resin repair of porcelain denture teeth and concluded that an effective temporary repair of fractured porcelain denture teeth involved abrasive treatment of the fractured tooth surface followed by a composite resin build up. This study also demonstrated that the best potential retention of the composite build up can be obtained through abrasive treatment by a coarse diamond stone.

Appledroon RE *et al.*1993 [7] investigated bond strength of composite resin to porcelain with newer generation porcelain repair systems and concluded that the Clearfil Porcelain Bond system developed a strong bond of composite resin to porcelain and maintained this bond over time and the porcelain repair systems that produced the greatest bond strengths generally produced the greatest number of cohesive failures in the porcelain, with the exception of the Etch-Free system.

Ferrando JMP *et al.* 1983 [8] studied tensile strength and micro leakage of porcelain repair materials and evaluated the tensile strength and micro leakage of five restorative resins bonded to porcelain and concluded that Enamelite 500 was superior to the four other materials in that it had the highest tensile strength and the least leakage at the resin porcelain interface. The study also concluded that bond strength of the repair systems could not be related to the degree of leakage.

Bello AJ *et al.* 1985 [9] evaluated the bond strength & micro leakage of porcelain repair materials and concluded that the tensile bond strength and micro leakage of four porcelain repair materials which were bonded to dental porcelain to simulate the repair of a ceramic restoration had a direct relationship and it was found that there is an increase in micro leakage and decrease in bond strength for the Silanit and Enamelite 500 exhibited the highest strength and the least amount of micro leakage.

Creugers NHJ *et al.* 1992 [10] analysed an experimental porcelain repair system & evaluated it under controlled clinical conditions for 6 to 12 months and concluded that the problem of wear and surface deterioration is not related to the repair system but to the use of micro filled composite resin (Prisma Fil) in their study. The study concluded that the surface deterioration could have been minimized if a (submicron) hybrid composite resin had been used.

Sulaiman AHA *et al.* 1993 [11] evaluated the effects of surface treatment & bonding agents on bond strength composite resin to porcelain and concluded that the most effective surface treatment was a combination of mechanical roughening with a diamond bur and chemical etching with hydrofluoric acid which provided slightly greater repair strengths than either method separately.

Tylka DF *et al.* 1994 [12] conducted a scanning electron microscopic study to compare the photomicrographs for porcelain composite repair systems and concluded that gross differences in the photomicrographs between the etch created by the acidulated phosphor fluoride gel and hydrofluoric acid resembled those published in earlier studies. All samples experienced cohesive failure of the porcelain to composite-resin bond and that shear bond strength of the repair by use of hydrofluoric acid or acidulated phosphor fluoride gel showed a greater cohesive strength.

Thurmond WJ *et al.* 1994 [13] analysed the effect of porcelain surface treatments on bond strengths of composite resin bonded to porcelain and concluded that mechanical alteration of a porcelain surface is more important than agents that promote chemical bonding of composite resin to porcelain. Porcelain treatment with a combination of aluminium oxide air abrasion and hydrofluoric acid provided higher bond strengths than treatment with either procedure alone.

Tulunoglu IF *et al.*2000 [14] evaluated resin shear bond strength to porcelain and a base metal alloy using two polymerization schemes and concluded that higher bond strength values were obtained with prepolymerized resin superstructures compared to in situ polymerized superstructures.

Haselton DR *et al.*2001[15] evaluated shear bond strengths of two intraoral porcelain repair systems to porcelain or metal substrates and concluded that both porcelain repair systems tested exhibited reasonable bond strengths to porcelain alone, porcelain/alloy, and ceramic alloy alone.

Ozcan M *et al.*2003 [16] reviewed on causes for fracture in ceramic fused to metal restorations and concluded that clinical studies showed the prevalence of ceramic fractures are between 5 to 10% over 10 years of use.

Acharya GS *et al.*2012 [17] assessed the effect of surface treatments and bonding regimens on micro tensile bond strengths of repaired composite and concluded that bond strength obtained by surface treatment with coarse diamond point is significantly higher than that obtained by surface treatment with silicon carbide and also that total-etch bonding regimen produced higher bond strength compared to treatment with silane primer and bonding resin application.

Tomar SS *et al.*2015 [18] evaluated the bond strength of metal crowns with different luting agents after various modes of surface treatments and concluded that, maximum bond strength was obtained by sandblasting with 110 μm alumina & ultrasonic cleaning, among all types of surface treatments used in their study and that the best luting agent was resin-modified glass ionomer cement.

Silva CB *et al.*2014 [19] studied the influence of surface treatments on bond strength of resin cements to nickel alloy and concluded that the surface treatment of the metal promoted a more effective bonding of the resin cements Panavia Fluoro Cement and Rely X ARC to the Ni-Cr alloy when compared to untreated surfaces.

Kim WH *et al.*2007[20] analysed the effect of ceramic surface treatments on the shear bond strength of dental composite resin to all ceramic coping materials and concluded that for the alumina and zirconia ceramic with thermo cycling, airborne-particle abrasion and acid etching had little influence on bond strengths between composite resin and ceramic materials. On the other hand, lithium disilicate ceramic and feldspathic ceramic showed higher bonding strengths after treated with airborne-particle abrasion.

Deepak K *et al* .2013[21] compared & evaluated the effect of laser on shear bond strength of ceramic bonded with two base metal alloys & concluded that the shear bond strength between ceramic bonded with Chromium-Cobalt alloys using the laser etching was higher than that with Nickel-Chromium alloys. And that laser surface treatment produced excellent surface roughness & achieved good shear bond strength values.

Grover N *et al.*2015[22] evaluated the effect of sandblasting and laser surface treatment on the shear bond strength of a composite resin to the facial surface of primary anterior stainless steel crowns and concluded that laser surface treatment obtained the highest bond strength.

Gourav R *et al.*2016[23] studied the effect of four different surface treatments on shear bond strength of three porcelain repair systems and concluded that surface treatment with sandblasting exhibited the highest shear bond strength followed by combined sandblasting & acid etching.

Mohselhifard E *et al.*2016[24] compared the effect of Nd: YAG laser and sandblasting on shear bond strength of a commercial Nickel-Chromium alloy to porcelain and concluded that Nd: YAG laser increases the shear bond strength of Nickel-Chromium alloy to porcelain.

Tjan AHL *et al.*1987[25] evaluated the bond strength of composite to metal mediated by metal adhesive promoters and concluded that the bond strengths attained with these tested metal primers are in general not high. Further research is needed for the development of a metal primer with an improved adhesive strength. Until then, dentists should continue to use the current methods of undercutting and roughening the metal surface in order to achieve additional retention.

Aida M *et al.*1995[26] studied the adhesion of composite to porcelain with various surface conditions and concluded that formation of siloxane bond was important for adhesion between composite resin & porcelain. Scanning electron microscope study showed that hydrofluoric acid etching gave highest roughness on porcelain surface.

Bello AJ *et al.*1985[27] evaluated the tensile bond strength & micro leakage of porcelain repair materials and concluded that all materials except Silanit increased in strength over the 4-week interval of this study. Enamelite 500 exhibited the highest strength at 4 weeks and the least amount of micro leakage.

Atsu SS *et al.* 2006[28] studied the effect of zirconium oxide ceramic surface treatments on the bond strength to adhesive resin and concluded that tribochemical silica coating (CoJet System) and the application of an MDP–containing bonding/silane coupling agent mixture increased the shear bond strength between zirconium-oxide ceramic and resin luting agent (Panavia F).

Beck AD *et al.*1990[29] analyzed the shear bond strength of composite resin porcelain repair materials bonded to metal & porcelain and concluded that bond strengths of composite resin materials to porcelain are significantly greater than those to either machined or oxidized alloy. Bond strengths of Ultra-Bond/Cerinate Prime/Gold Link materials were not significantly different from Profile/ Fusion Resin/Prisms Universal Bond materials. Bond strengths varied significantly for different types of porcelain, and different types of alloys used as substitutes.

Borges AG *et al.*2003[30] investigated the effect of etching & air borne particle abrasion on the microstructure of different dental ceramics and concluded that hydrofluoric acid etching and airborne particle abrasion with aluminum oxide increased the irregularities on the surface of IPS Empress, IPS Empress 2, and Cergogold ceramics. Similar treatment of In-Ceram Alumina, In-Ceram Zirconia, and Procera did not change their morphologic microstructure.

Hasegawa T *et al.*1995[31] studied the shear bond strength & quantitative microleakage of a multipurpose dental adhesive system resin bonded to dentin and concluded that excellent shear bond strength values of 13.9 MPa to 19.5 MPa were obtained and microleakage values obtained were favorable compared to other dentin bonding systems.

Kelly JR *et al.*1996[32] reviewed ceramics in dentistry: its historical roots & current perspectives and concluded that recent progress includes the advent of predictable ceramic materials and techniques for esthetic complete crowns, partial coverage, and laminate veneer restorations; improved metal-ceramic esthetics with the advent of opalescent porcelains and framework modifications; introduction of CAD/CAM and machining as a route to fabrication of restorations; and improved understanding of the clinical response of all-ceramic prostheses and of the materials factors that influence clinical longevity.

Kupiec KR *et al.*1996[33] evaluated porcelain surface treatments & agents for composite to porcelain repair & concluded that the combination of aluminum oxide air abrasion and hydrofluoric acid treatment of a porcelain surface provided an optimal surface for composite bonding with the ProBond system. Silane treatment of porcelain was critical for obtaining suitable bond strengths of composites to porcelain.

Lacy AM *et al.*1988[34] studied the effect of porcelain surface treatment on the bond to composite and concluded that the silane coupling agent was effective in establishing a bond between composite and dental porcelain.

Nowlin TP *et al.*1981[35] evaluated the bonding of three porcelain repair systems and concluded that fractured porcelain bars repaired with Fusion/ Concise displayed significantly greater repair strength ($ < .05) than bars repaired with Den-Mat and Cervident2.

Pratt RC *et al.*1989[36] evaluated bond strength of six porcelain repair systems and concluded that porcelain repair products are significantly affected by aging and that all products had a significant loss of bond strength after 3 months, suggesting that porcelain repairs may be an interim clinical procedure.

Robert JD *et al.*1979[37] reviewed repair of porcelain fused to metal restorations and concluded that the composite resin bonded to porcelain repair technique will not have as favorable a prognosis, as composite resins were subjected to more wear, were not color stable, and the chemical bond created with bonding agents was much weaker than the bond created when porcelain is fused to metal.

Highton RM *et al.*1979[38] studied the effectiveness of porcelain repair systems and concluded that the surfaces of the fractured and repaired beams revealed that the failure occurred at the porcelain-resin interface, which indicates that the bonding agent rather than the resin failed in all specimens.

Kussano MC *et al.*2003[39] evaluated shear bond strength of composite to porcelain on the basis of surface treatment and concluded that the combination of sandblasting with acids on porcelain salinization provided the best results and it was also observed that silane priming considerably improved bond strength to the porcelain of the composite material.

Al Edris A *et al.*1990[40] conducted scanning electron microscopic evaluation of etch patterns by three etchants on three porcelains & concluded that etch patterns were noticeably different for the three porcelain and that Hydrofluoric acid in combination with other acid produced similar etch patterns on all three porcelains.

Arnold DAM *et al.*1989[41] evaluated the bond strengths of intraoral porcelain repair materials & concluded that fusion and scotch prime materials achieved bond strengths to nonglazed porcelain in excess of the shearing resistance of the porcelain. Cerinate prime material failed to achieve as strong a bond.

Bailey JH *et al.*1989[42] evaluated porcelain to composite bond strengths using four organosilane materials & concluded that there is no significant differences between the flexural strength of 3M Porcelain Repair Kit product with Scotch prime Ceramic Primer product, the Fusion product, or the Sybron 'Kerr Ultrafine Porcelain Repair Bonding System product with the Silux composite.

Arnold DAM *et al.*1989[43] evaluated the bond strengths of four organosilane materials in response to thermal stress and concluded that thermocycling caused a statistically significant decrease in the mean shear bond strength of Command Ultrafine Porcelain Repair system, Enamelite 500, and Fusion systems. The Scotchprime system maintained consistently high shear bond strength values under the conditions tested.

Ahamadzadeh A *et al.*2016[44] studied effect of silane on shear bond strength of two porcelain repair systems and concluded that ultra-dent ceramic repair kit yields higher shear bond strength at ceramic composite interface compared to pulp dent ceramic repair kit. Use of one or two layers of silane does not make any significant with regard to the shear bond strength of ceramic to composite.

Khoroushi M *et al.*2007[45] analyzed shear bond strength of composite-resin to porcelain - effect of thermocycling and concluded that silane treatment of porcelain was critical for achieving durable bond strength between composite – resin and porcelain.

Ozel GS *et al.*2016[46] compared shear bond strength of three different composite materials to metal and ceramic surfaces and concluded that Kuraray CL groups revealed highest bond strength resulted from MDP content and 40% thixotropic acid efficiency in both metal and porcelain substrates. The bond strength of Ultradent RK group is the lowest among metal groups.

Shah K *et al.*2016[47]reviewed dental ceramics – past, present and future and concluded that the increased demand for aesthetics led to the development of all ceramic restorations. Zirconia is one of the most stable ceramics and has flexural strength and toughness values almost two times higher than those produced by glass ceramics.

Kesark P *et al.*2012[48] investigated surface hardness of resin cement polymerized under different ceramic materials and concluded that surface hardness is one of the most effect methods to evaluate polymerization of resin cement. Surface hardness decreased significantly moving from top towards bottom of the specimen. Resin cements polymerized under different ceramic materials and thicknesses showed statistically significant differences in knop hardness number.

Young Yoo J *et al.*2015[49] evaluated porcelain repair-influence of different systems and surface treatments on resin bond strength and concluded that airborne-particle abrasion and application of repair system I can be recommended in the case of a fracture localized to the porcelain. If the fracture extends to metal surface, the repair system II is worthy of consideration.

Raposo LHA *et al.*2009[50] studied ceramic restoration repair clinically and concluded that the repair performed with composite resin is an esthetic and functional alternative when extensive fixed partial dentures cannot be replaced. Adequate bond between ceramics and composite resin is achieved with a silane coupling agent and an adhesive.

MATERIALS AND METHODOLOGY

Although routine use of ceramics in restorative dentistry is a recent phenomenon, the desire for a durable and esthetic material is ancient. Most cultures through the centuries have acknowledged teeth as an integral facial structure for health, youth, beauty, and dignity. Teeth have routinely been designated with an equally powerful, if occasionally perverse, role in cultures where dentitions were purposely mutilated as inspired by vanity, fashion, mystical and religious beliefs. Therefore, it has been almost universal that unexpected loss of tooth structure particularly, missing anterior teeth create physical and functional problems and often psychologic and social disturbances as well. Although dental technology existed as early as 700 BC and during the Roman first century BC, it remained virtually undeveloped until the eighteenth century. Materials for artificial teeth fabrication during the 18th century were (1) human teeth (2) animal teeth carved to the size and shape of human teeth (3) ivory and (4) “mineral” or porcelain teeth. Other than for costly human teeth that were scarce, the selection of artificial tooth materials was based on their mechanical versatility and biologic stability. Animal teeth were unstable toward the “corrosive agents” in saliva, and elephant ivory and bone contained pores that easily stained. Hippopotamus ivory appears to have been more desirable than other esthetic dental substitutes[32].

Porcelain fused to metal crowns have been used as predictable materials since 1960’s owing to their mechanical strength & low cost. Porcelain repair systems are a good option for saving an existing structurally sound crown or bridge with esthetic damage. Intraoral repair using a Bis – GMA composite light cured resin can be an alternative method that offers great benefits due to its superior aesthetics color stability and ease of application. Various techniques for the preparation of exposed surfaces have also been introduced to improve the bonding qualities between metal or porcelain substrates and resin composites[49].

The objective of the present study was to evaluate the shear bond strength of two different ceramic repair systems (Ivoclar & Shofu) with two different surface treatments (sandblasting using intraoral sandblaster & laser etching using intraoral Nd:YAG laser unit). Scanning electron microscopic study of the surfaces of the metal blocks were also done to assess differences between laser etched surface & sandblasted surface.

Materials & Equipment

1) Cobalt Chromium blocks (25mm X 8mm X 8mm) – 20 no's
2) Pattern wax (GEO Crowax Renfert Company)
3) Investment material (Castorite Dentarum Company)
4) Cobalt Chromium ingots (Colado cc, Ivoclar Company)
5) Centrifugal casting machine (Luka Dent –Germany)
6) Polyvinyl silicone impression material (Aquasil ,DENTSPLY)
7) Ivoclar Ceramic repair system (Ceramic Repair N Ivoclar Vivadent Clinical –Germany)

8) Shofu Ceramic repair system (P&R Repair kit ,CRB Resin bond 1&2 USA)
9) Light cure unit (Suz-Dent (India) Pvt ltd, Naranpura, Ahmedabad)
10) Intraoral Sandblaster (Bio-art Microjato microblaster)
11) Distilled water (Excel Demineralised water)
12) Ultrasonic Cleaner (Confident ultrasonic cleaner CO-80-L)
13) Laser unit (ND: YAG laser) (Fotona fidelis plus III, Slovenia)
14) Universal testing Machine (Model :3345, INSTRON)
15) Scanning Electron Microscope (S 2400, Hitachi)

In the present study, shear bond strength of two ceramic repair systems are evaluated, they are Ceramic Repair N system kit of Ivoclar Vivadent Clinical and P&R Repair kit of Shofu. Ceramic repair kit of ivoclar has monobond N, heliobond, opaquer, three shades of composite resin and applicator tips. P and R repair kit of shofu has metal primer, cerarésin bond 1 and 2 and applicator tips. Shofu beautifill composite II was coated on cobalt chromium metal surface after application of P and R repair kit.

Groups

Four groups were there in the present study. Group I, II, III & IV.

Group I - Sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system.

Group II - Laser etched cobalt chromium metal surface coated with Ivoclar ceramic repair system.

Group III Sandblasted cobalt chromium metal surface coated with Shofu ceramic repair system.

Group IV Laser etched cobalt chromium metal surface coated with Shofu ceramic repair system.

Methodology

In the present study a stainless steel metal die of 25mm length, 8mm width & 8mm thickness was milled. The die was duplicated using polyvinyl siloxane impression material (Aquasil, Dentsply) for fabrication of 20 cobalt chromium blocks. Wax patterns (Geo, Crowax) were made with the duplicated mould. Patterns were then removed from the mould before investing (Castorite Dentarum Company). The cobalt chromium blocks were casted using automated centrifugal casting machine (Luka-Dent Germany). These blocks were divided into two groups of 10 numbers each. Each block was marked 6mm from the edge using diamond point (shofu 101).

Ten such blocks were sandblasted using of 110µ size of alumina particles (Aluminox) for 15 seconds using intraoral sandblaster (Bio-art, Microjato microblaster) and then cleansed using ultrasonic cleaner (Confident Ultrasonic Cleaner CO-80-L) with distilled water (Excel Demineralised Water). Ivoclar ceramic repair system (Ivoclar Ceramic Repair N) was bonded on the sandblasted surface of five blocks (4mm×4mm×4mm) and Shofu ceramic repair system (P&R CRB Bond 1&2) was bonded on the sandblasted surface of the remaining five blocks (4mm×4mm×4mm)

The remaining ten cobalt chromium blocks were laser etched using ND: YAG laser (Fotona fidelis plus III, Slovenia) in pulsative mode at a power setting of 6W, 120mj & 50Hz frequency for 60 seconds. Ivoclar ceramic repair system(Ivoclar Ceramic Repair N) was bonded on the laser etched surface of five blocks (4mm×4mm×4mm)and Shofu ceramic repair system(P&R CRB Bond 1&2) was bonded on the laser etched surface of the remaining five blocks (4mm×4mm×4mm).

A sharp ended chisel tool was made. The study to evaluate shear bond strength was done in the Division of Polymeric Sciences, Bio Medical wing of Sree Chithira Tirunal Institute of Medical Sciences and Technology poojappura, Trivandrum. The cobalt chromium blocks were loaded on to the large Jig of Universal Testing Machine (Instron model 3345).The tool was fixed on the Universal Testing Machine. Test method used was compression mode with a test speed of 1.0mm/min and sample was tested with 5kN load cell. The shear bond strength was calculated using the formula:-

Shear bond strength = Force/Area

Scanning Electron Microscopic study was done in the Division of Bio ceramics, Sree Chithira Tirunal Institute of Medical Sciences and Technology Poojappura, Trivandrum. Scanning electron microscopic (S2400 Hitachi) study of the sandblasted & laser etched surfaces of cobalt chromium metal blocks were done to assess the difference in roughness of the surface of the blocks. Both the sandblasted and laser etched surfaces of metal were gold coated in Ion Sputter machine before scanning electron microscopic evaluation was done. Then the surface to be studied was marked with a marker pen. Each surfaces were studied in three magnifications of 500X, 1000X and 2000X. In all the three magnifications the sandblasted surface showed maximum irregularities and maximum roughness. The laser etched surface showed maximum smooth uniform polished surface in all the three magnifications of 500X, 1000X and 2000X. The Scanning electron microscopic study go hand in hand with the results of present study which gave maximum value for shear bond strength of sandblasted specimens than the laser etched ones.

FIGURES

Fig 1- Wax pattern made for Cobalt-Chromium metal block

Fig 2-Lukadent Casting Machine

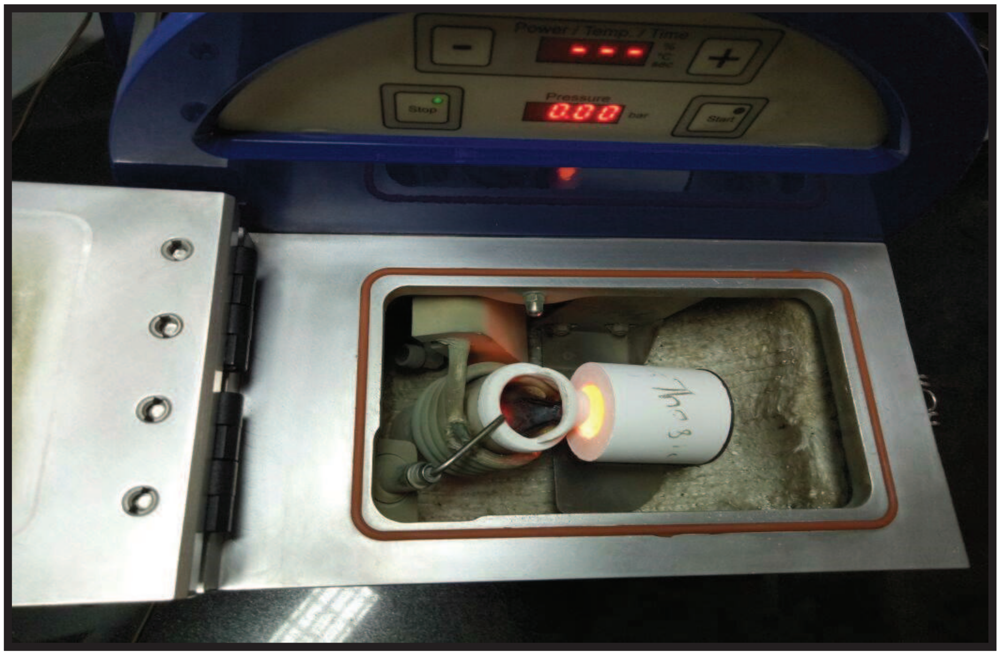


Fig 3- Casting process

Fig 4 -Cobalt-Chromium metal block

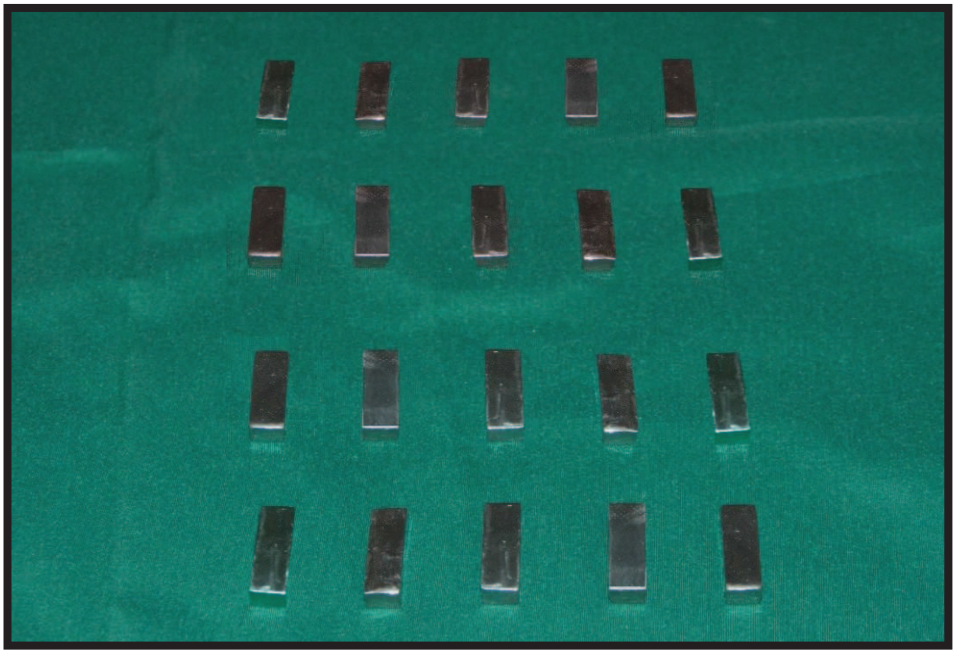


Fig 5- Cobalt-Chromium metal blocks

Fig 6- 6mm marked on Cobalt-Chromium metal block

Fig 7- Intra Oral Sandblaster

Fig 8- Alumina particles (110μ)

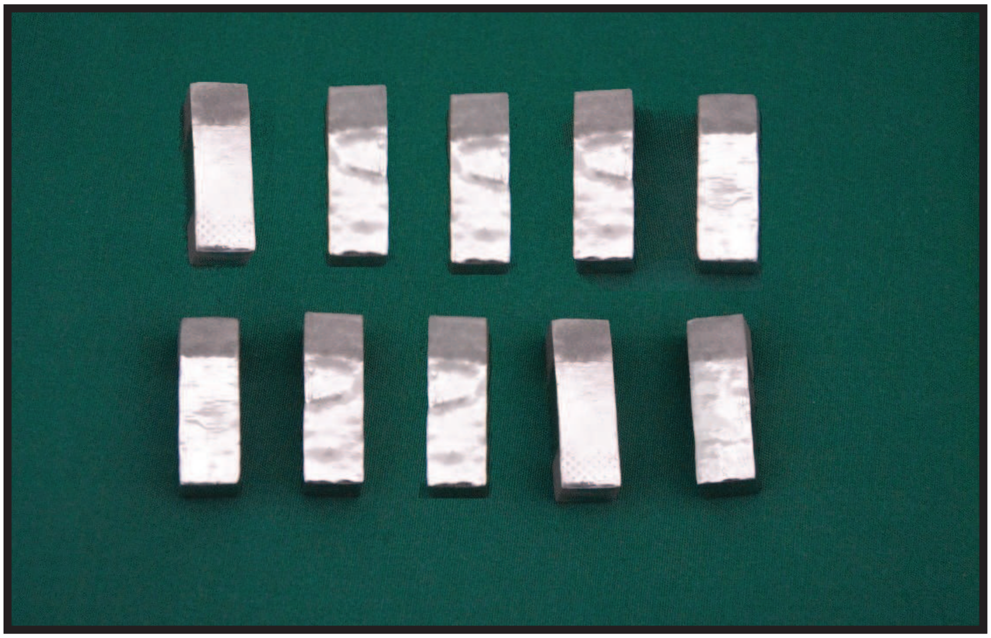


Fig 9- Sandblasted Cobalt-Chromium blocks

Fig 10- Ultrasonic cleaner

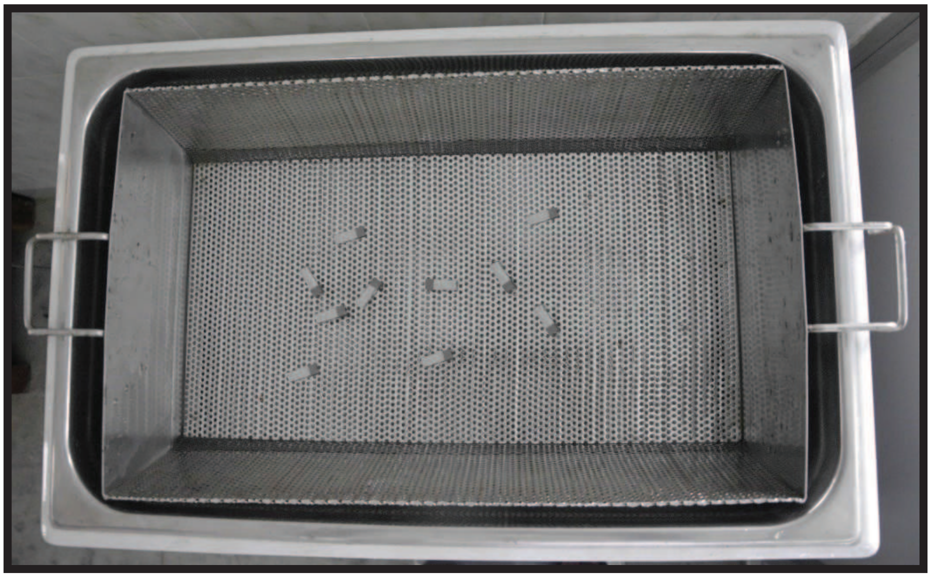


Fig11-Sandblasted Cobalt-Chromium metal blocks in ultrasonic cleaner

Fig 12- Demineralised water

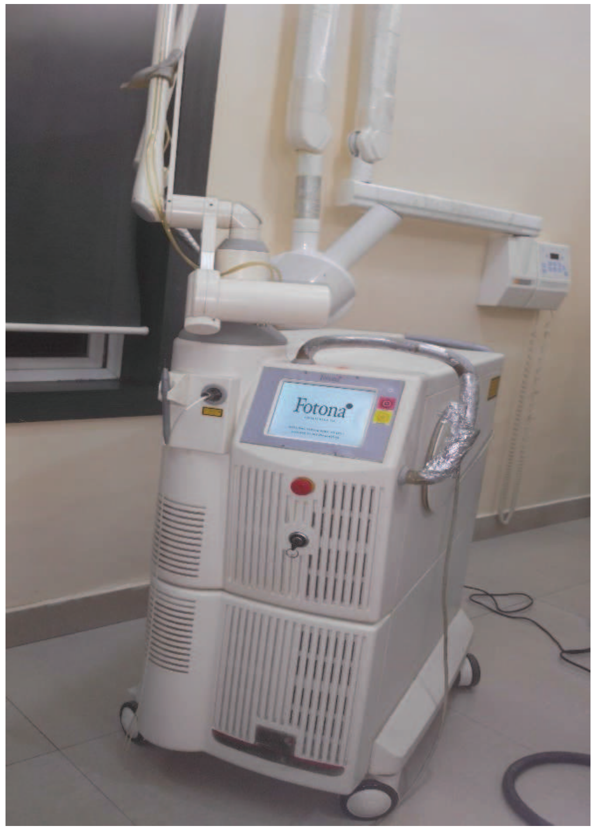


Fig 13- Nd:YAG intra oral laser unit

Fig 14- Laser etching process

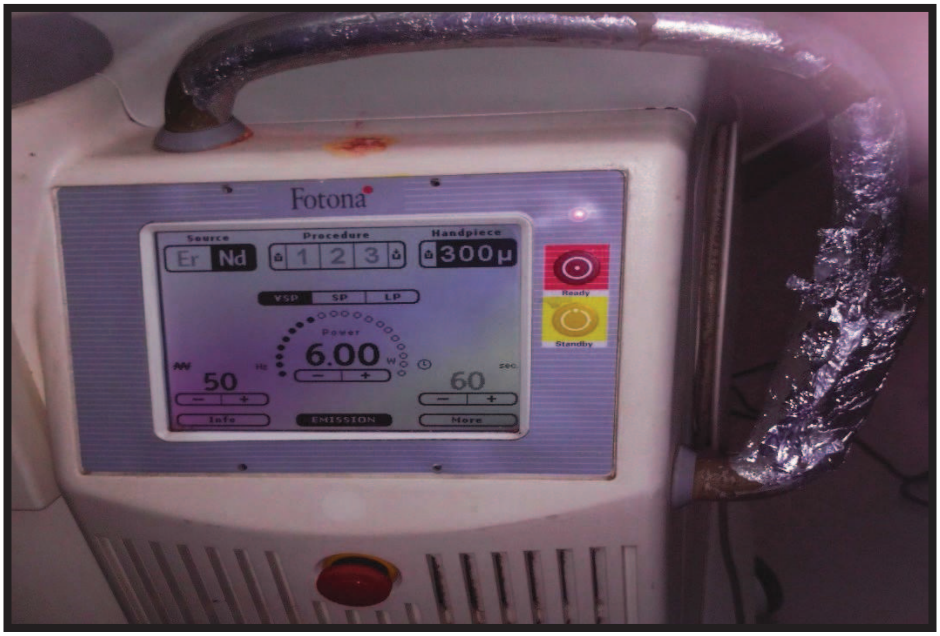


Fig 15- Power setting of Laser unit

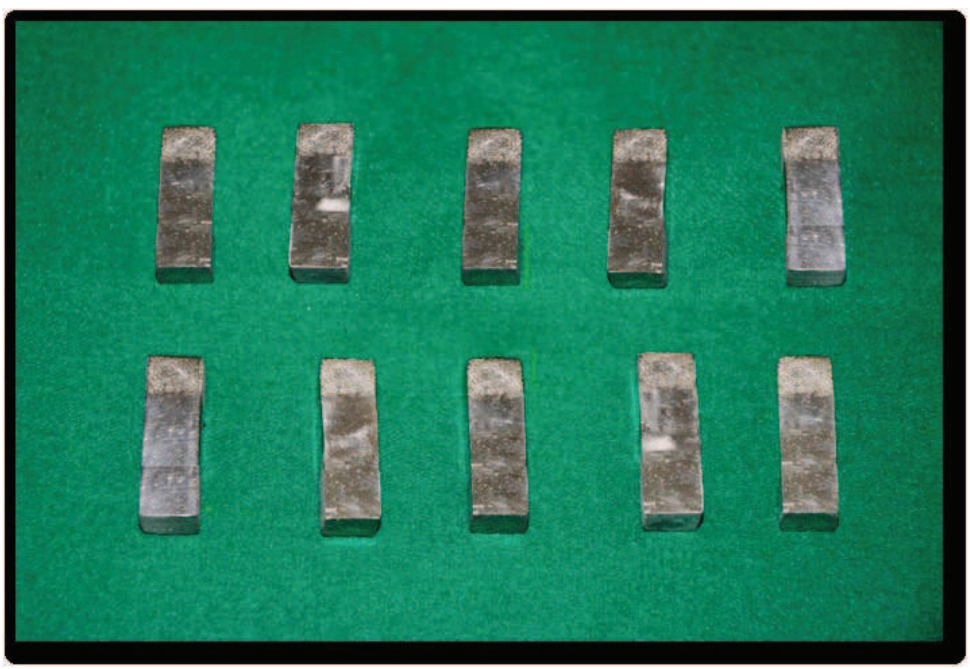


Fig 16- Laser etched Cobalt-Chromium blocks

Fig 17- Ivoclar ceramic repair kit

Fig 18- Ivoclar ceramic repair kit

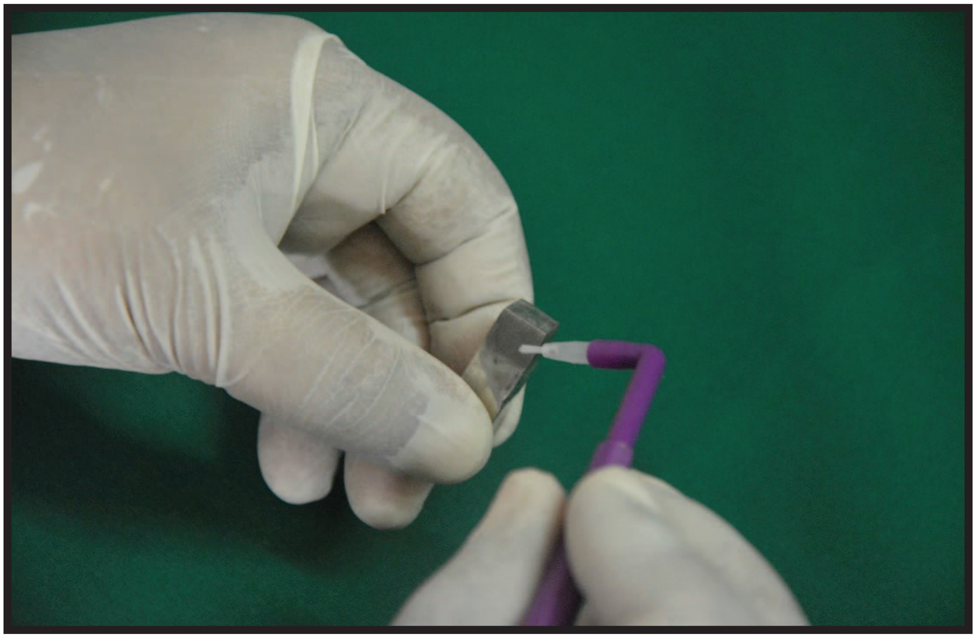


Fig 19- Ivoclar-Heliobond application

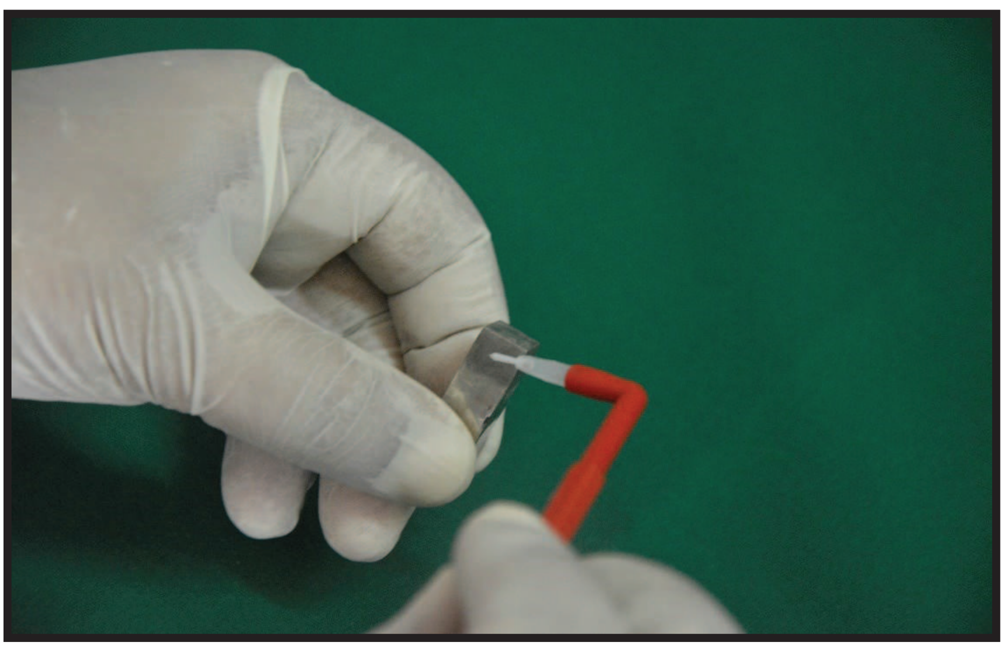


Fig 20- Ivoclar - Monobond application

Fig 21- Shofu Ceramic repair kit

Fig 22- Shofu Ceramic repair kit

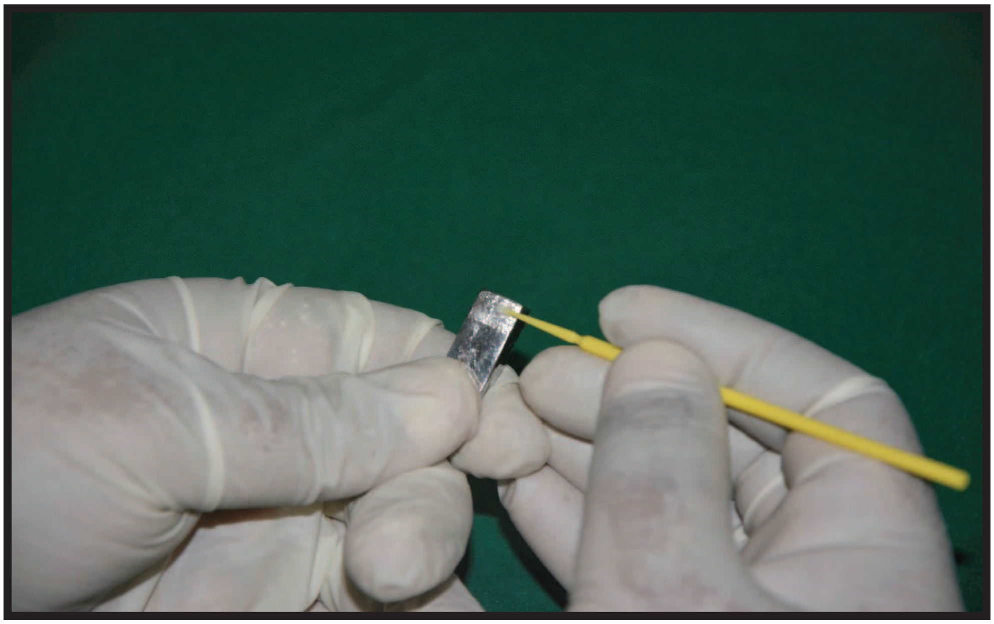


Fig 23- Shofu metal primer application

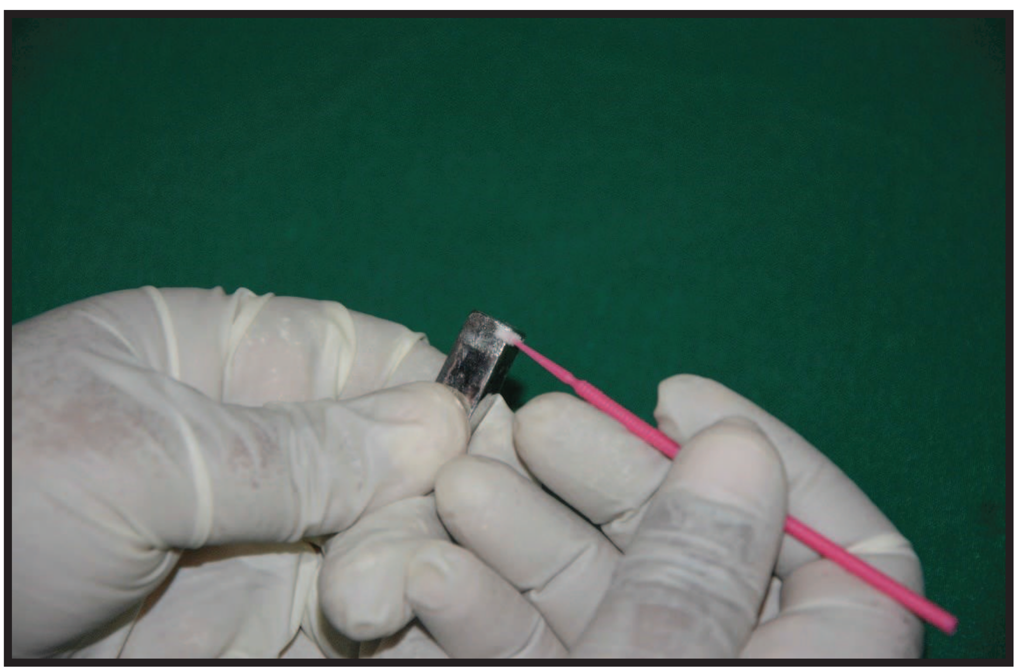
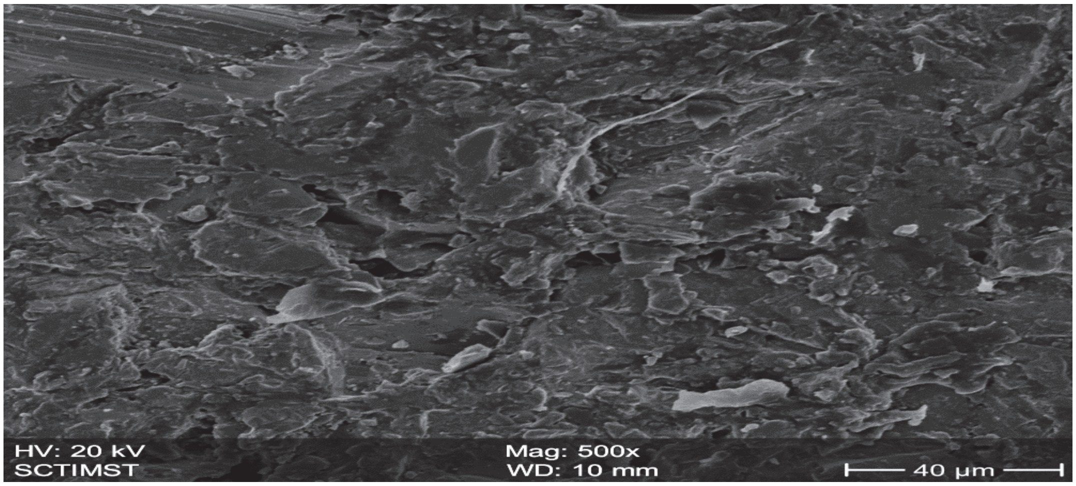


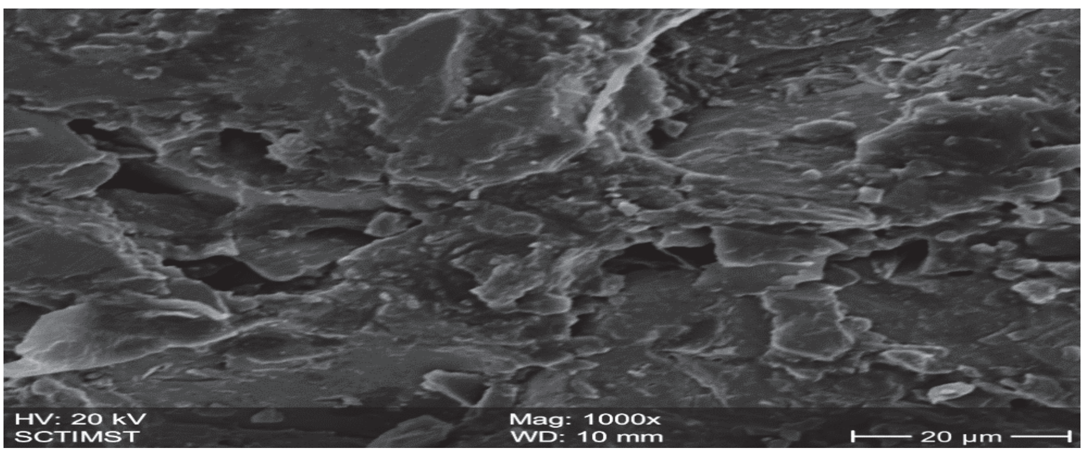
Fig 24- Shofu Cera Resin Bond 1 & 2

Fig 25- Ceramic repair system curing done using composite curing light cure unit

Fig 26- Cobalt-Chromium metal block with light cured ceramic repair system

Fig 27- Scanning electron microscopic image of sandblasted specimen





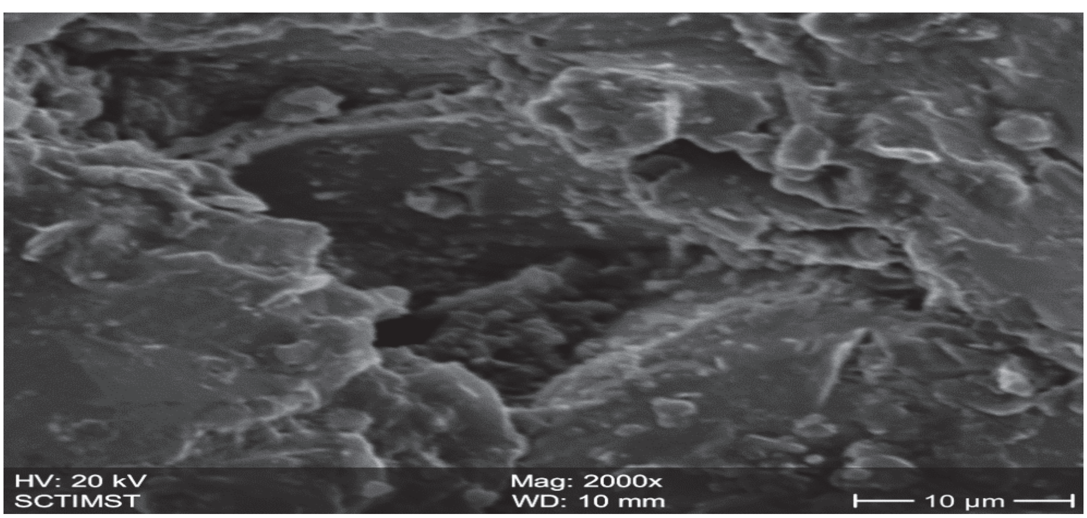


Fig 28- Scanning electron microscopic image of Laser etched specimen

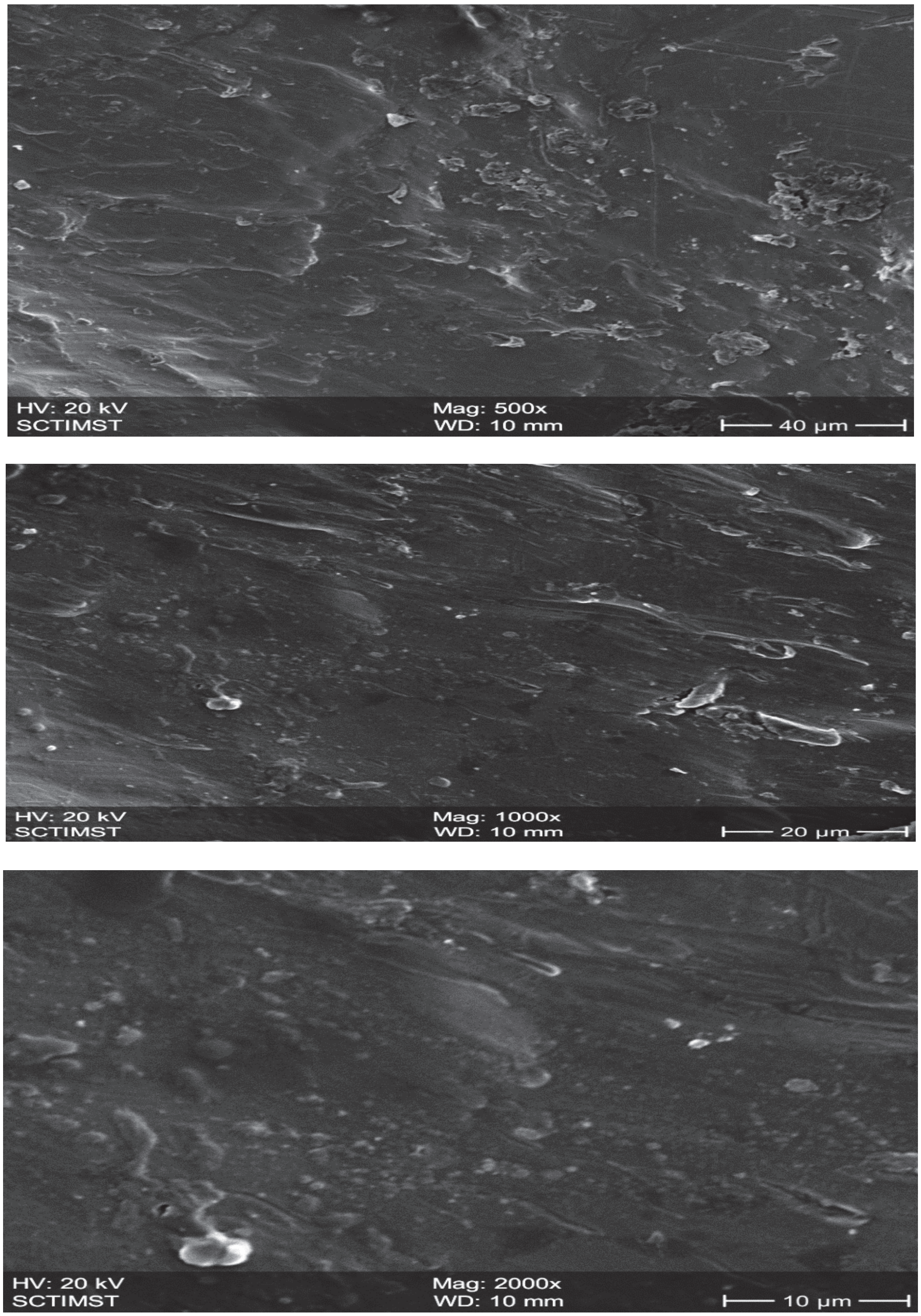


Fig 29- Scanning electron microscope

Fig 30- Ion sputter machine

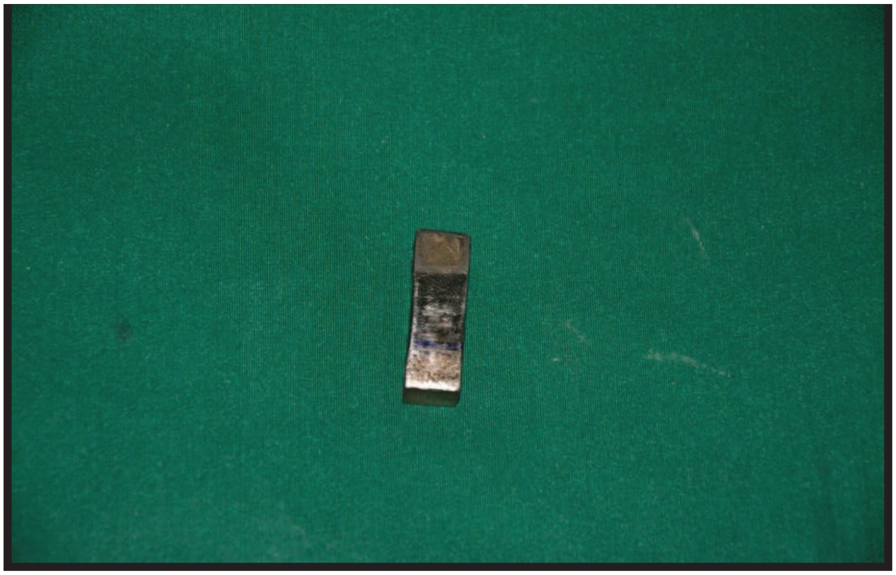


Fig 31- Gold coating on sandblasted Cobalt-Chromium metal block

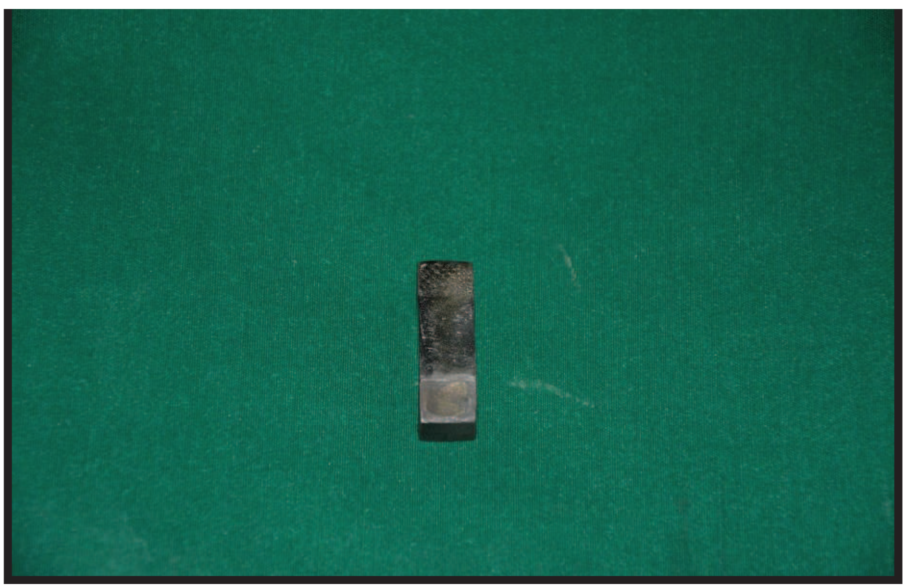


Fig 32- Gold coating on laser etched Cobalt-Chromium metal block

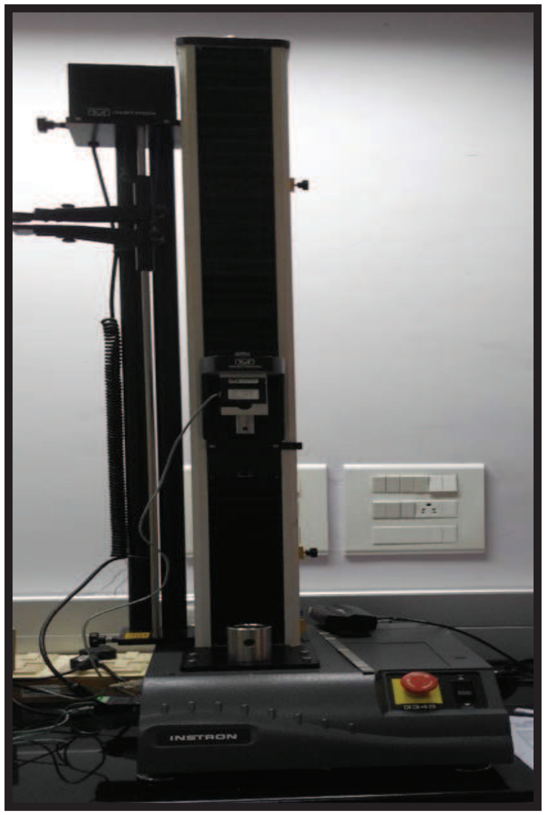


Fig 33- Universal testing machine

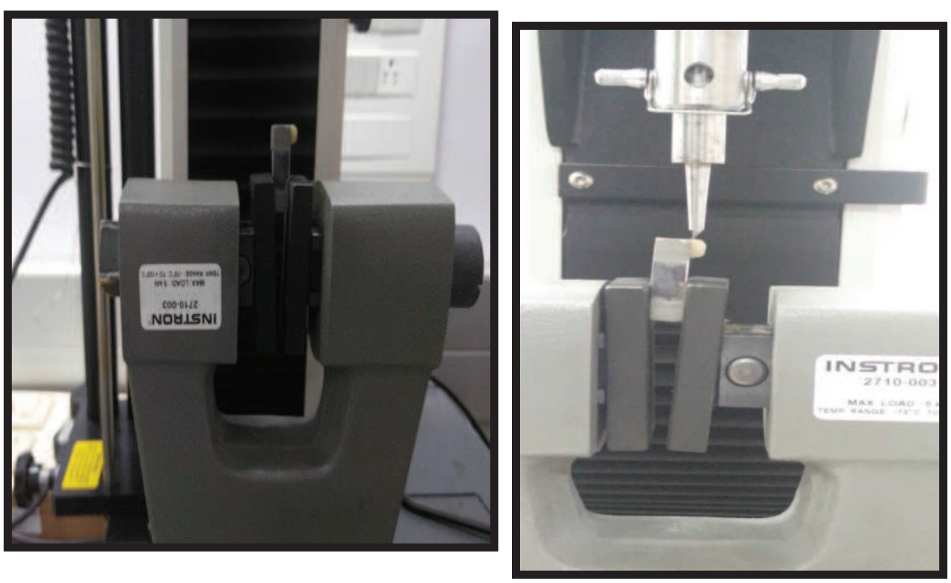


Fig 34- Jig and Specimen in place

RESULTS AND OBSERVATIONS

The present study evaluated the shear bond strength of sandblasted and laser etched cobalt chromium metal surface coated with Ivoclar and Shofu ceramic repair systems. For all groups the shear bond strength assessment were done.

Description of Groups

Four groups were there in the present study. Group I, II, III & IV.

Group I - Sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system.

Group II - Laser etched cobalt chromium metal surface coated with Ivoclar ceramic repair system.

Group III - Sandblasted cobalt chromium metal surface coated with Shofu ceramic repair system.

Group IV - Laser etched cobalt chromium metal surface coated with Shofu ceramic repair system.

RESULTS

The data was expressed in mean and standard deviation. Statistical Package for Social Sciences (SPSS 16.0) version used for analysis. ANOVA (Analysis of variance) (Post hoc) followed by Dunnet t test were applied to find the statistical significance between the groups. P value less than 0.05 ($p<0.05$) is considered statistically significant at 95% confidence interval.

Table-1: Mean Max load and Shear Bond Strength values of different groups

Groups	Treatment	Max load (MEAN±SD)	Shear Bond Strength (MPa) (MEAN±SD)
Group-I	**Ivoclar sand blasting**	411.81±1.25	25.73±7.84
Group-II	**Ivoclar laser**	126.41±6.03	7.90±3.77
Group-III	**SHOFU sandblasting**	296.53±3.76	18.53±2.35
Group-IV	**SHOFU laser**	181.29±6.96	11.23±4.43

According to Table-1:-

a) For Group I (Sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system) the mean maximum load applied is 411N and the mean shear bond strength value obtained is 25.73 MPa.

b) For Group II (Laser etched cobalt chromium metal surface coated with Ivoclar ceramic repair system) the mean maximum load applied is 126 N and the mean shear bond strength value obtained is 7.9 MPa.

c) For Group III (Sandblasted cobalt chromium metal surface coated with Shofu ceramic repair system) the mean maximum load applied is 296 N and the mean shear bond strength value obtained is 18.53MPa.

d) For Group IV (Laser etched cobalt chromium metal surface coated with

Shofu ceramic repair system) the mean maximum load applied is 181N and the mean shear bond strength value obtained is 11.23MPa.

Group I (Sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system) has the highest shear bond strength value compared to all other groups.

Table-2: Comparison of mean Max load and Shear Bond Strength values of Group-I with other groups

Groups	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-I	411.81±1.25		25.73±7.84	
Group-II	126.41±6.03*	**0.001**	7.90±3.77*	**0.001**
Group-III	296.53±3.76*	**0.002**	18.53±2.35*	**0.04**
Group-IV	181.29±6.96*	**0.001**	11.23±4.43*	**0.02**

(*p<0.05 significant compared Group-I with other groups)

Table 2 compared the mean shear bond strength values of Group I with other groups where probability value less than 0.05 is significant. Probability value of Group II is 0.001, Group III is 0.04 and Group IV is 0.02 which is statistically significant.

When a mean maximum 411.81N load was applied for Group I a mean shear bond strength value of 25.73 MPa is obtained. When a mean maximum load of 126.41N was applied for Group II a mean shear bond strength of

7.90MPa is obtained. When a mean maximum load of 296.53N was applied for Group III a mean shear bond strength of 18.53 MPa was obtained. When a mean maximum load of 181.29N was applied for Group IV a mean shear bond strength of 11.23 MPa is obtained. The maximum force applied is that force which when reached the ceramic breaks of from the metal substrate. Shear Bond strength is obtained by dividing the Force from Area.

Shear bond strength = Force/Area.

Table-3: Comparison of mean Max load and Shear Bond Strength values of Group-II with other groups

Groups	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-II	126.41±6.03		7.90±3.77	
Group-I	411.81±1.25*	**0.001**	25.73±7.84*	**0.001**
Group-III	296.53±3.76*	**0.001**	18.53±2.35*	**0.001**
Group-IV	181.29±6.96*	**0.002**	11.23±4.43*	**0.002**

(*p<0.05 significant compared Group-II with other groups)

Table 3 compared the mean shear bond strength values of Group II with other groups where probability value less than 0.05 is significant. Probability value of Group I is 0.001, Group III is 0.001, Group IV is 0.002 which is statistically significant.

Group II showed the lowest shear bond strength values compared to all other groups. Group I showed three times higher value for shear bond strength than Group II. Group III showed two times higher value for shear bond strength than Group II. Group IV also showed higher value for shear bond strength compared to Group II. The lowest value for shear bond strength was recorded for laser etched cobalt chromium metal surface coated with Ivoclar Ceramic repair system (GroupII).

Table-4: Comparison of mean Max load and Shear Bond Strength values of Group-III with other groups

Groups	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-III	296.53±3.76		18.53±2.35	
Group-I	411.81±1.25*	**0.002**	25.73±7.84*	**0.04**
Group-II	126.41±6.03*	**0.001**	7.90±3.77*	**0.001**
Group-IV	181.29±6.96*	**0.001**	11.23±4.43*	**0.002**

(*p<0.05 significant compared Group-III with other groups)

Table 4 compared the mean shear bond strength values of Group III with other groups where probability value less than 0.05 is significant. Probability value of Group I is 0.04, Group II is 0.001, Group IV is 0.002 which is statistically significant.

When shear bond strength of Group III is compared with other three groups it is two and a half times higher than that of Group II, one and a half times higher than that of Group IV but it is less than that of Group I.

Table-5: Comparison of mean Max load and Shear Bond Strength values of Group-IV with other groups

Groups	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-IV	181.29±6.96		11.23±4.43	
Group-I	411.81±1.25*	**0.001**	25.73±7.84*	**0.02**
Group-II	126.41±6.03*	**0.002**	7.90±3.77*	**0.002**
Group-III	296.53±3.76*	**0.001**	18.53±2.35*	**0.04**

(*p<0.05 significant compared Group-IV with other groups)

Table 5 compared the mean shear bond strength values of Group IV with other groups where probability value less than 0.05 is significant**.** Probability value of Group I is 0.02, Group II is 0.002, Group III is 0.04 which is statistically significant.

When shear bond strength of Group IV is compared with other three groups it is one and a half times lesser than that of Group III, two and a half times lesser than that of Group I but it is higher than that of Group II.

Table-6: Multiple comparison of mean Max load and Shear Bond Strength values of different groups

Groups	Max load (MEAN±SD)	Shear Bond Strength (MPa) (MEAN±SD)
Group-I	411.81±1.25	25.73±7.84
Group-II	126.41±6.03*	7.90±3.77*
Group-III	296.53±3.76*,#	18.53±2.35*,#
Group-IV	181.29±6.96*,#,$	11.23±4.43*,#,$

(*$p<0.05$ significant compared Group-I with other groups, #$p<0.05$ significant compared Group-II with other groups, $p<0.05 significant compared Group-III with other groups)

Table 6 is multiple comparison of mean shear bond strength values of different groups in which Group I (sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system) has highest value for shear bond strength followed by Group III (sandblasted cobalt chromium metal surface coated with Shofu ceramic repair system).

25.73 MPa was the mean shear bond strength obtained at a mean maximum load for 411.81N for Group I. 18.53MPa was the mean shear bond strength obtained at a mean maximum load for 296.53N for Group III. 11.23MPa was the mean shear bond strength obtained at a mean maximum load for 181.29N for Group IV. 7.90MPa was the mean shear bond strength obtained at a mean maximum load for 126.41N for Group II.

Table-7: Comparison of mean Max load and Shear Bond strength values between Group-I and Group-II

Groups	Treatment	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-I	**Ivoclar sand blasting**	411.81±1.25	**0.001**	25.73±7.84	**0.001**
Group-II	**Ivoclar laser**	126.41±6.03*		7.90±3.77*	

(*p<0.05 significant compared Group-I with Group-II)

Table 7 compared shear bond strength values of Group I and II which has a probability value of 0.001 which is statistically significant. Shear bond strength values indicate that sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system (Group I) has three times higher strength than laser etched cobalt chromium metal surface coated with Ivoclar ceramic repair system (Group II).

The values of shear bond strength indicate the major role of surface treatments on metal substrate. The same Ivoclar ceramic repair system shows both highest and lowest values of shear bond strength according to the type of surface treatment (sandblasting and laser etching) on the cobalt chromium metal surface.

Table-8: Comparison of mean Max load and Shear Bond strength values between Group-III and Group-IV

Groups	Treatment	Max load (MEAN±SD)	P value	Shear Bond Strength (MPa) (MEAN±SD)	P value
Group-III	**SHOFU sandblasting**	296.53±3.76	**0.001**	18.53±2.35	**0.04**
Group-IV	**SHOFU laser**	181.29±6.96*		11.23±4.43*	

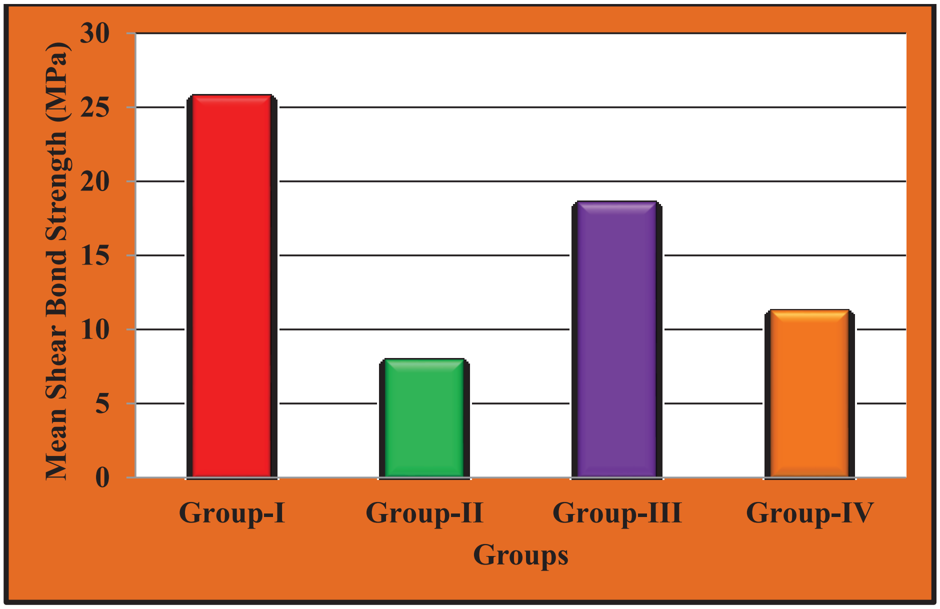
(*p<0.05 significant compared Group-III with Group-IV)

Table 8 shows the comparison of mean shear bond strength values of Group III and IV which has a probability value of 0.04 which is statistically significant. Shear bond strength values indicate that sandblasted cobalt chromium metal surface coated with Shofu ceramic repair system (Group III) has higher strength than laser etched cobalt chromium metal surface coated with Shofu ceramic repair system (Group IV).

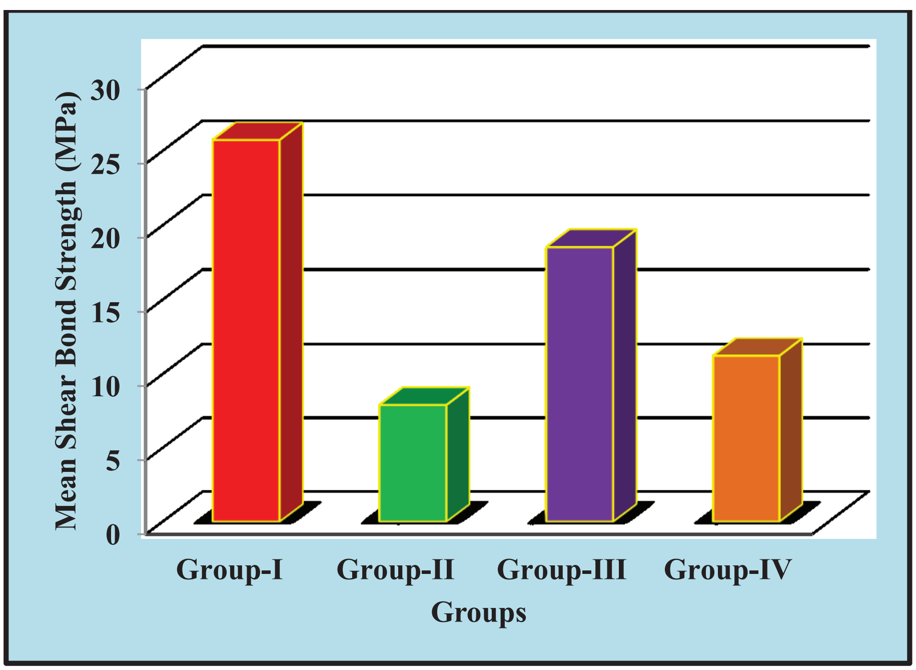
SEM RESULTS

GRAPHS

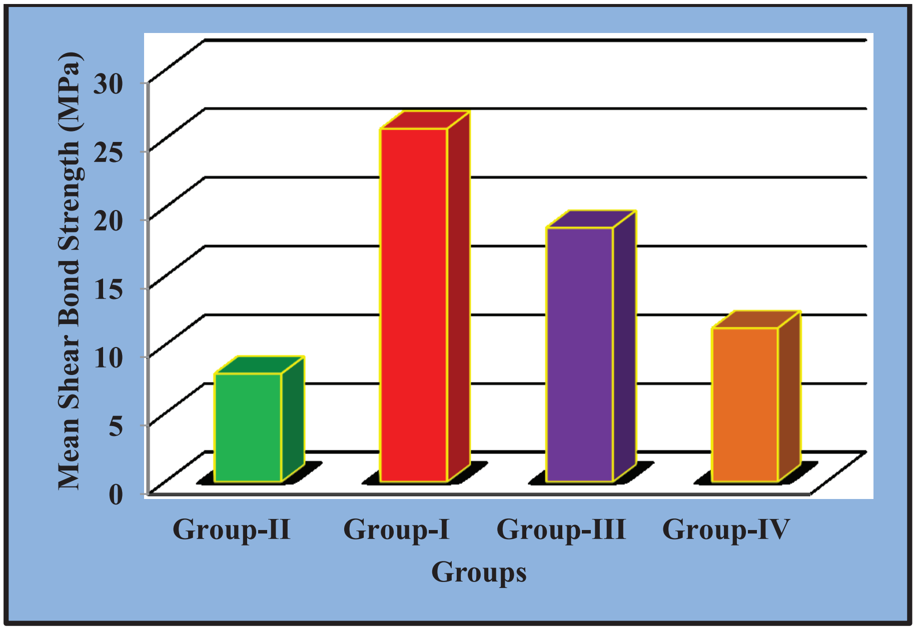
Graph-1: Graph depicting Mean Shear Bond Strength values of different groups



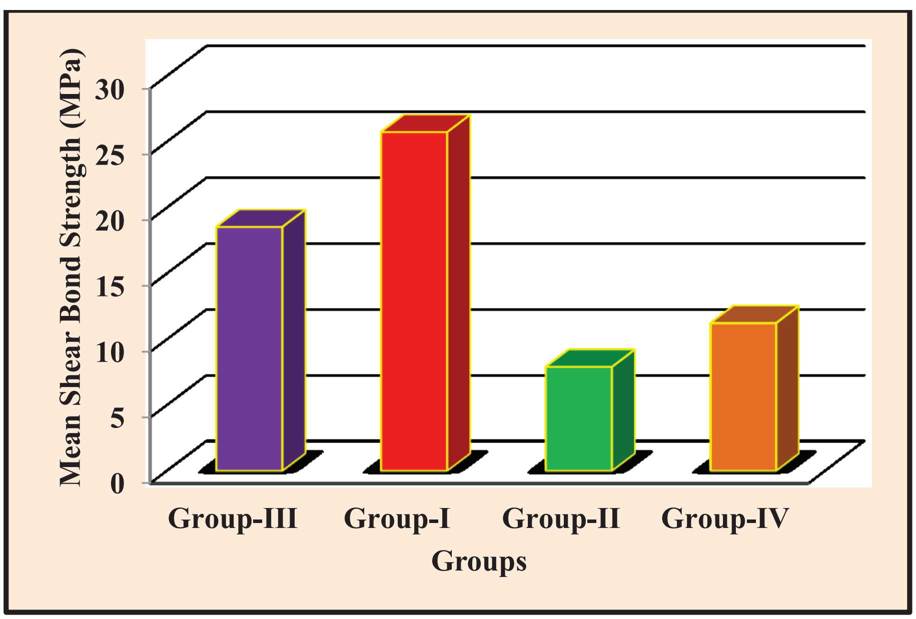
Graph-2: Graph depicting Comparison of mean Max load and Shear Bond Strength values of Group-I with other groups



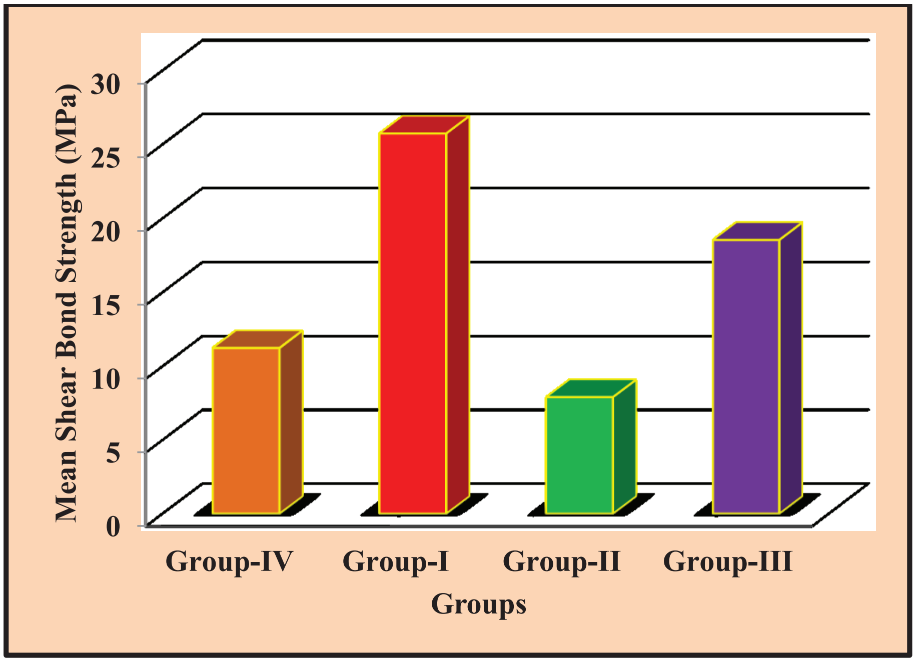
Graph-3: Graph depicting Comparison of mean Max load and Shear Bond Strength values of Group-II with other groups



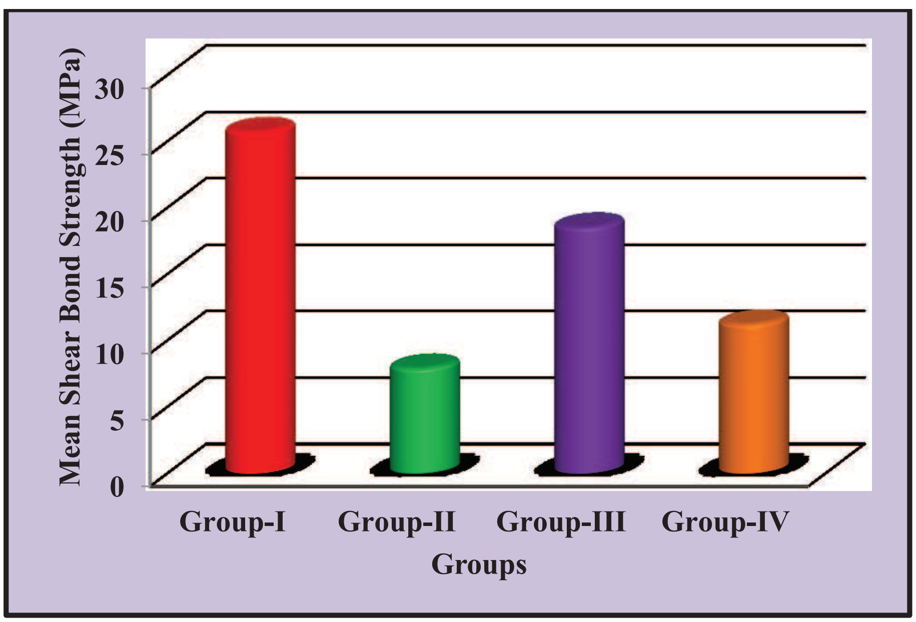
Graph-4: Graph depicting Comparison of mean Max load and Shear Bond Strength values of Group-III with other groups



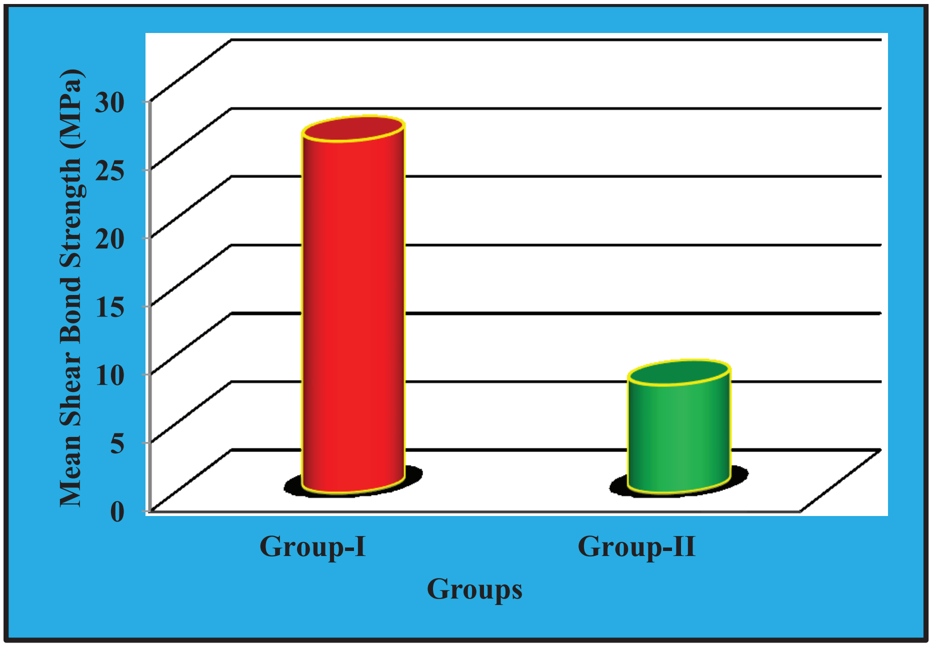
Graph-5: Graph depicting Comparison of mean Max load and Shear Bond Strength values of Group-IV with other groups



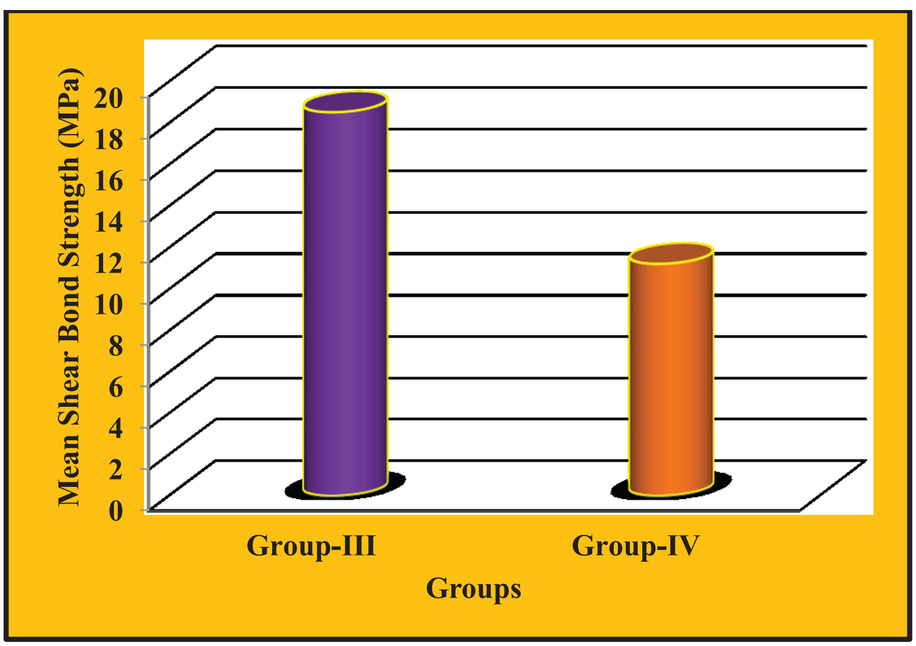
Graph-6: Graph depicting multiple comparison of mean Max load and Shear Bond Strength values of different groups



Graph-7: Graph depicting comparison of mean Max load and Shear Bond strength values between Group-I and Group-II



Graph-8: Graph depicting comparison of mean Max load and Shear Bond strength values between Group-III and Group-IV



DISCUSSION

Metal-ceramic restorations are widely used in restorative dentistry with a high degree of success. On occasions, fractures do occur in ceramic as a result of trauma, metal flexure, or ceramic fatigue, and a decision on how to rectify the resultant defect needs to be made. Fractured porcelains will affect aesthetics and function of the prostheses, which may warrant patients to seek immediate treatment. One option is to remake the restoration. This is both expensive and time consuming. Removal and reconstruction of the prostheses is a costly affair, and it is therefore worthy to attempt repair with composite resins intra-orally, especially in less severe cases. An easy alternative is to repair the deficiency using one of the many proprietary porcelain repair systems. However, for the repair to withstand functional loads, the bond between the repair material and remaining restoration must be strong and durable[23]. Metal–ceramic prostheses must have satisfactory bond strength of the metal substructure to porcelain to exhibit clinical longevity. Due to the high cost of precious alloys, since the 1970s and after progresses made in ceramic technology, base metal (Ni–Cr and Co–Cr) casting alloys are often selected. Nickel– chromium (Ni–Cr) dental alloy has been used to prepare metal-ceramic crowns and fixed partial dentures more commonly. Its mechanical properties enable the fabrication of restorations with a satisfactory hardness with lower thickness. The thermal expansion coefficient of Ni–Cr dental alloy is matched to that of conventional porcelain[24].

Three conditions which are usually suggested for repair of metal ceramic restorations are: - Fracture in porcelain with no metal exposure, fracture with both porcelain and metal exposure and fracture with substantial metal exposure. Mechanical and chemical bonding methods have been recommended to enhance the bond strength of these composite resins to metal ceramic restorations. Various surface treatments to increase the mechanical bonding like roughening with diamond bur and air abrasion with aluminium oxide can be used to condition the surfaces of the both metal and ceramic. Acid etching with hydrofluoric acid, acidulated phosphofluoride or ammonium hydrogen bifluoride can be done in ceramics. Chemical bonding using adhesive primers and silane coupling agents enhance bonding after initial mechanical surface treatments.The improvement in adhesion of composites to base metals and ceramic can be made by the addition of adhesive primers to various composite formulations to enhance bonding to sandblasted base metal and ceramic surfaces[23].

Metal-ceramic restorations have been available for approximately 35 years. During this period, substantial improvement in alloy substrates and veneering porcelains have resulted in widespread acceptance of metal-ceramic restorations. Continued research efforts have led to a more detailed, practical understanding of metal-ceramic systems[32].Porcelain-fused-to-metal crowns have been used as predictable materials since the 1960s, owing to their mechanical strength and low cost. However, porcelain veneer failure has been reported as the major cause for the replacement of metal-ceramic restorations. The fracture of veneering porcelain may result from trauma, improper metal framework design, incompatibility between the thermal expansion coefficient of the porcelain and core, inadequate tooth preparation, inadequate occlusal adjustment, and intraceramic defects. The rate of failure caused by porcelain fracture is reported in the literature to be approximately 2-16% and the majority of failures (65%) are observed in the anterior region, and mainly in the maxilla (75%), predominantly at the labial surface. Also, failure may often occur in the anterior regions, presenting a serious aesthetic problem. The immediate replacement of failed complex prostheses is often impossible though, as it requires additional time, effort, and expense. In this situation, repair is a suitable method to rehabilitate the contour and colour of fractured restorations. Such repair demands durable bonding, even though it is not a permanent treatment.[49]

Intraoral ceramic repair system enhances the mechano-chemical bond between resin and metal or ceramic substrate by mechanically increasing the surface area, decreasing the surface tension and by causing physical alteration which promoted adhesion of resin to porous surface of metal ceramic restoration. Anterior ceramic restorations are primarily subjected to shear stress and the shear bond test is considered appropriate for quantifying the strength of intra oral porcelain repairs. It is evident from data available in literature that anterior metal ceramic restorations are more prone for fracture[1].

Ceramic repair systems are composed of nano-composites or hybrid composites which are made of polymer groups as organic phase and an inorganic phase with a composition of glass particles and silica as micro fillers. There are various commercially available ceramic repair system kits. In the present study, shear bond strength of two ceramic repair systems are evaluated, they are Ceramic Repair N system kit of Ivoclar Vivadent Clinical and P&R Repair kit of Shofu. Ceramic repair kit of Ivoclar has monobond N, heliobond, opaquer, three shades of composite resin and applicator tips. P and R repair kit of shofu has metal primer, ceraresin bond 1 and 2 and applicator tips. Shofu beautifill composite II was coated on metal specimen after application of P and R repair kit (shofu).

Intraoral porcelain repair presents many difficulties for the clinician. Methods of surface preparation must be carefully controlled to minimize potential health hazards to patients and dental personnel, and aggressive mechanical and chemical agents must be avoided[2]. Arnold et al[41]reported that the chemical interaction between silane coupling agent, composite & dental porcelain should result in a stable and predictable bond.

In present study the shear bond strength of Ivoclar & Shofu ceramic repair systems were assessed after surface treatments with laser etching and sandblasting on the cobalt chromium metal surface. Various literature reviews suggests that air abrasion with alumina particles followed by acid etching gives the high shear bond strength value. A shear test was chosen for the present study because multiple substrates were used.

In addition, anterior restorations are subjected primarily to shear stresses, and the shear test is considered appropriate for quantifying the strength of porcelain repairs[15].

Yavuz et al[5] stated that the properties of a luting agent and the surface treatment for ceramic surfaces before cement application plays a major role in the clinical success of many indirect ceramic restorations. The purpose of the present study was also to assess the best surface treatment available for metal surface. Air borne particle abrasion with alumina particles (110µ) is effective and practical for creating an activated and roughened surface. Sandblasting produces a rough irregular surface with an increased surface area and enhances wettability of the ceramic or composite resin. Particle size, procedure duration, pressure and distance used in the procedure are important factors in the performance of a cement bond[5].

Pratt et al[7] reported on the mean shear bond strengths of composite resin bonded to porcelain with the use of six porcelain repair systems. All six porcelain repair systems evaluated in their study exhibited a significant decrease in the bond strength of composite resin to porcelain after 3 months of 37ºC water storage and 24 hours of thermo cycling. In their study Scotch prime system produced the highest shear bond strength 6.2 MPa after 3 months of water storage and thermocycling[7].

In the present study, the shear bond strength of Ivoclar ceramic repair system showed the highest value of 25.73Mpa. Among the two surface treatments the sandblasted specimen (coated with Ivoclar) gave this highest value for shear bond strength. In the present study when laser etching was done and compared, the cobalt chromium metal surface coated with Shofu ceramic repair system gave the highest value of 11.23MPa. The effects of these surface treatments were determined by measuring the bond strengths achieved between the composite resin and the metal surface[13].

Intraoral sandblasting was shown to be the most efficient surface treatment than intraoral laser etching with Nd: YAG laser. Sulaiman AH et al[11] reported that the most effective surface treatment was a combination of mechanical roughening with a diamond bur and chemical etching with hydrofluoric acid. This combination provided slightly greater repair strengths than either method separately.

Adhesion of polymers to dissimilar surfaces is a dynamic equilibrium. Requirements for optimal adhesion include: (1) intimate interfacial contact between surfaces; (2) the ability of the interface to withstand polymerization shrinkage and thermal stresses; and (3) the ability of the interface to withstand the presence of water[43].

Torsional loading as applied in the present study allowed the generation of a uniform state of stress along the sample. All fractures in this study were spiral in nature and thus cohesive. This means that the shear bond strength of the porcelain-to-composite resin interface was superior to the cohesive strength of the porcelain and composite resin materials as tested[12].

Scanning microscopy of the sandblasted cobalt chromium metal surface and laser etched cobalt chromium metal surface were done after gold was coated on these surfaces using Ion Sputter machine.Scanning electron microscopy with all three magnifications (500X, 1000X, and 2000X) revealed that more surface roughness was there in sandblasted metal substrate than the laser etched one. The laser etched metal substrate showed uniformly polished surface in all the three magnifications.

The difficulty in intraoral sandblasting was that proper isolation should be there with rubber dam as alumina particles are used inside the oral cavity. Even in intraoral laser etching there should be proper isolation and the power setting should be managed properly without causing any harm to the intraoral soft tissues and hard tissues.

In the present study the sandblasted cobalt chromium metal surface coated with Ivoclar ceramic repair system has the highest shear bond strength value than all the other groups. From the laser etched cobalt chromium specimens the highest value for shear bond strength was obtained for the Shofu ceramic repair system. The results showed that surface treatments have a major role in the shear bond strength of ceramic repair systems.

The present study had limitations in its ability to simulate clinical loading forces on restorations and oral environmental changes. In the shear bond test, the loading was monotonic instead of representative of cyclic fatigue, and the temperature and moisture of the oral cavity were not simulated; these factors should be included in investigations as many factors affect the bond strengths of the resin luting cements applied to the ceramics. Future studies with a model that more closely resembles the oral environment and simulates clinical loading conditions are required for more strong evidence based shear bond strength values.

SUMMARY AND CONCLUSION

Ceramic-fused-to-metal restorations are widely used in dentistry with a high degree of general success. Fracture of the ceramic veneers as a result of oral function or trauma is not an uncommon problem in clinical practice. Although fractures of such restorations do not necessarily mean failure of the restoration, the renewal process is both costly and time consuming and therefore remains a clinical problem. Fractures in the anterior region pose an aesthetic problem but when they are in the posterior, chewing function could also be affected[16].

The present study was done to compare and analyze the shear bond strength of Ivoclar and Shofu ceramic repair systems after it has been coated on sandblasted and laser etched cobalt chromium metal surface. The study also revealed that the efficiency of the type of surface treatment is important in determining the shear bond strength of various ceramic repair systems.

Mechanical alteration of fractured ceramic and exposed metal substrate is a pre requisite for chair side intraoral repair. This mechanical alteration increases mechano-chemical bond between the metal substrate & bonding agent in different commercially available ceramic repair system kits. The metal primer or the silane coupling agent available in the ceramic repair kit makes the bond stronger by sialinization of the metal substrate.

The results of the study indicated that out of the four groups the 1st group that is sandblasted cobalt chromium surface coated with Ivoclar ceramic repair system gave the highest value for shear bond strength. The second group that is the laser etched cobalt chromium surface coated with Ivoclar ceramic repair system gave the lowest value for shear bond strength.

When the results were evaluated the importance of an efficient surface treatment was proved. Ivoclar ceramic repair system gave both the highest & lowest shear bond strength values. The efficiency of the ceramic repair system depends solely on the type of surface treatment the metal substrate received and the type of bond formed with the metal and porcelain.

Within the limits of the present study it can be concluded that:-

- Group I – sandblasted cobalt chromium metal blocks coated with Ivoclar ceramic repair system showed highest shear bond strength than all other three groups.
- Surface treatment with sandblasting or air abrasion with 110μ alumina particles gave better result for shear bond strength assessment.
- For sandblasted groups, Ivoclar ceramic repair system gave the better shear bond strength value.
- For laser etched groups, Shofu ceramic repair system gave the better shear bond strength value.

However further clinical research is suggested in order to prove it as a reliable and successful treatment modality.

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